Development and Screening of Remedial Alternatives Memorandum

Berry’s Creek Study Area

Prepared for

Berry’s Creek Cooperating PRP Group

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amsl	above mean sea level
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
ASM	Adaptive Site Management
BAZ	Biologically Active Zone
BCC	Berry’s Creek Canal
BCSA	Berry’s Creek Study Area
CDM	Camp Dresser & McKee
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Constituent of Potential Concern
CSM	Conceptual Site Model
CTM	Candidate Technologies Memorandum
DoD	U.S. Department of Defense
DSRAM	Development and Screening of Remedial Alternatives Memorandum
ELM	Environmental Liability Management
EMNR	Enhanced Monitored Natural Recovery
EPA	United States Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
FS	Feasibility Study
GRA	General Response Actions
GSR	Green and Sustainable Remediation
IC	Institutional Controls
ITRC	Interstate Technology and Regulatory Council
LBC	Lower Berry’s Creek
MBC	Middle Berry’s Creek
MIT	Massachusetts Institute of Technology
MIT CAU	MIT Center for Advanced Urbanism
MNR	Monitored Natural Recovery
NAVFAC	Naval Facilities Engineering Command
NCP	National Contingency Plan
NGO	Non-Governmental Organization
NJDEP	New Jersey Department of Environmental Protection
NJDOH	New Jersey Department of Health

NJMC	New Jersey Meadowlands Commission
NJMRC	New Jersey Meadowlands Regional Commerce
NJSEA	New Jersey Sports and Exposition Authority
NRC	National Research Council
OSWER	Office of Solid Waste and Emergency Response
PCB	Polychlorinated Biphenyl
PRP	Potentially Responsible Party
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RI	Remedial Investigation
SAWP	Scoping Activities Work Plan
SMU	Sediment Management Unit
SOW	Statement of Work
STP	Sewage Treatment Plant
TAL	Target Analyte List
UBC	Upper Berry’s Creek
UOP	Universal Oil Products
UPIC	Upper Peach Island Creek
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WRTG	West Riser Tide Gate
ZVI	Zero Valent Iron

SECTION 1

INTRODUCTION

1.1 Overview

The Development and Screening of Remedial Alternatives Memorandum (DSRAM) builds upon the Candidate Technologies Memorandum (CTM) (Geosyntec/Integral, 2010) in identifying and evaluating the suite of remedial alternatives to be considered in the detailed alternatives analysis in the Feasibility Study (FS) for the Berry's Creek Study Area (BCSA or Site). Preparation of the DSRAM is a requirement of the Administrative Order on Consent (AOC) Statement of Work (SOW) and the BCSA Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Geosyntec/Integral, 2009).

The DSRAM documents the methods, rationale, and results of the remedial alternatives development and screening process for the BCSA waterways and marsh areas. (Note: waterways consist of both mudflat and subtidal geomorphological features; marsh areas are typically vegetated). The DSRAM advances the FS process toward the detailed alternatives analysis and completion of the FS, which will include evaluation of the interaction between remedial components for marshes and waterways.

1.2 Objectives

The United States Environmental Protection Agency's (EPA's) Guidance for Conducting Remedial Investigation and Feasibility Study under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA [EPA, 1988]) states that:

> *"The primary objective of this phase of the FS is to develop an appropriate range of waste management options that will be analyzed more fully in the detailed analysis phase of the FS."*

For the BCSA FS, the objectives of the DSRAM effort are to:

- Develop a range of remedial alternatives for the conditions in the BCSA.
- Evaluate and screen the developed alternatives based on effectiveness, implementability, and cost according to EPA's Contaminated Sediment Remediation Guidance (EPA, 2005); and screen out alternatives that are deemed to be ineffective, not implementable, or incompatible with Site-specific conditions in the BCSA.
- Retain those alternatives that may apply to the BCSA conditions and identify key attributes for consideration in the detailed alternatives evaluation process.

- Present an approach to the detailed evaluation of the remedial alternatives for the BCSA.

The BCSA is a large and complex tidal waterway and marsh landscape with distinct areas that have widely differing hydrologic, geochemical, and contaminant profiles. A single remedial approach would not be effective for the entire BCSA and the eventual remedial action will comprise combinations of actions applied to specific areas within the system. Furthermore, as stated in EPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, alternatives that combine a variety of approaches are frequently cost-effective for large or complex sites and yield higher net environmental benefit (EPA, 2005) than approaches relying on a single technology.

The BCSA Statement of Work provides for evaluation of portions of the BCSA that are relatively distinct. Based on the extensive site characterization work completed to date, gradients of conditions are apparent from north to south throughout the study area. However, the most distinct differences are between waterways and marshes and these differences warrant separate evaluation of remedial alternatives. Accordingly, this development and screening of alternatives focuses on waterways and marshes separately. The subsequent detailed alternatives analysis will consider further delineated geomorphological features (i.e., separate evaluation of intertidal mudflats and subtidal channel in waterways) and combinations of waterway-marsh alternatives in portions of the study area.

In recognition of the large size of the BCSA, the multiple current and past sources of stressors, and likelihood of a long period of remedy implementation and monitoring, the AOC SOW calls for consideration of an Adaptive Site Management (ASM) approach for the remedial actions. ASM would allow remedial actions to be implemented in a sequenced and monitored fashion in which the results of the initial remedial actions would be monitored to evaluate remedy effectiveness, and the need for and scope of subsequent remedial components would be adapted to the conditions present after the initial action. This DSRAM was developed with recognition that ASM may be incorporated into the remedial action; however, since the scope of this DSRAM focuses on broad geomorphic areas rather than specific areas within the BCSA, specific consideration of potential adaptive components and sequencing of the remedy will be considered in the detailed alternatives analysis that is the next step in the FS process.

1.3 Feasibility Study and the Role of the Development and Screening of Remedial Alternatives

1.3.1 Feasibility Study Process

The FS is a systematic approach to evaluating methods to mitigate identified human health and ecological risks in the BCSA within the context of the specific nature of the Site and the planned future uses of the area. EPA (EPA, 2005) describes the use of a comparative approach to guide the selection of remedies with the objective of achieving net risk reduction while maintaining flexibility to identify a range of alternatives. The FS phases use this approach to identify and evaluate remedial alternatives based on the criteria established in the National Contingency Plan (NCP). The FS process, including the elements addressed in this DSRAM, is summarized in a simplified flow diagram in Figure 1-1. The process also includes review and comment steps that are not detailed on the simplified diagram.

1.3.2 Role of the DSRAM

The FS process begins with consideration of a wide range of remedial technologies that might contribute to achieving remedial action objectives (RAOs). This serves as the basis for proposing and selecting a remedy for the site that best eliminates, reduces, or controls risks to human health, ecological receptors, and the environment (EPA, 2005). The technologies are evaluated and winnowed down to those that are applicable for the specific site settings. From these technologies, remedial alternatives are developed and then screened to produce a list of alternatives to be considered in the detailed alternatives evaluation. The overall process is designed to ensure that appropriate remedial options are considered in a step-wise approach of evaluation and elimination to make the detailed analysis of alternatives efficient.

As shown in Figure 1-1, the elements of the FS process that are addressed in the DSRAM include:

- Refine preliminary RAOs;
- Identify Applicable or Relevant and Appropriate Requirements (ARARs);
- Develop potential remedial alternatives; and
- Evaluate and screen the developed remedial alternatives.

The DSRAM builds upon the work of the CTM (Geosyntec/Integral, 2010). The remedial technologies identified in the CTM that are potentially applicable for the BCSA were used as building blocks to develop potential remedial alternatives as presented in this DSRAM. The alternatives were then evaluated under the criteria set forth in the NCP and in accordance with EPA's RI/FS Guidance (EPA, 1988).

The DSRAM provides an opportunity for stakeholders to review and comment on preliminary RAOs, ARARs, and the remedial alternatives to be considered in developing potential remedies before the in-depth evaluation of technologies and development of alternatives begins. This memorandum also provides a preview of the detailed evaluation process for EPA input on the path forward.

1.4 BCSA Site Characteristics

1.4.1 Introduction

The presentation of BCSA Site characteristics reflects the findings of RI/FS activities performed to date, including background research and scoping activities performed pursuant to the Scoping Activities Work Plan (SAWP) (ELM, 2007), subsequent phases of the RI, the treatability and pilot studies, and on-going baseline monitoring. The Phase 2 Site Characterization Report (Geosyntec/Integral, 2012) provides a more extensive description of the Site setting and history.

1.4.2 Site Setting

The BCSA is located within the Hackensack River watershed as shown in Figure 1-2 and is part of the Hackensack Meadowlands. The BCSA is located in the Piedmont physiographic province which overlies Pleistocene lake bed deposits. The site boundary is the Berry's Creek watershed, which covers a total area of 7,690 acres. The focus of the CERCLA investigation is the tidal area in this fringing marsh system, which is a side embayment of the Hackensack River. The tidal portion of the BCSA is nearly flat, with elevations less than 10 feet (ft.) above mean sea level (amsl), with a few isolated knolls (NJ Meadowlands Commission [NJMC], 2004). The BCSA consists of three geomorphic areas: (i) waterways (including intertidal mudflats, subtidal primary channels and their tributaries), (ii) marshes primarily vegetated with *Phragmites*, and (iii) uplands.

BCSA uplands (i.e., land within the BCSA that is not open channel or wetlands) are approximately 85% developed and cover over 6,500 acres. Light industry is the most prevalent land use in upland areas with manufacturing as the dominant industry. Approximately 1,785 acres are developed as residential property.

A total of 872 acres of the BCSA are characterized as marsh areas, including 735 acres of emergent tidal marsh and 137 acres of tributaries and pools within the main marsh. An additional 161 acres are classified as waterways, including 60.9 acres of intertidal mudflat and 99.5 acres of subtidal channels.

Consistent with the BCSA SOW (Appendix B of the AOC), the RI/FS focuses on the tidally influenced portions of the BCSA. As such, the site features that are most relevant to the RI/FS and for which remedial alternatives are developed separately are the waterways and marshes (typically *Phragmites* marshes), because of their distinctly different physical settings and distinct mutual boundaries (i.e., the abrupt drop in elevation from marsh plain to waterway). An additional distinction is made between (i) the main tidal portion of the BCSA (marshes and waterways) below tide gates and (ii) tidally-influenced areas above tide gates. Accordingly, the discussion of the Site Setting is presented in two major sections below: (i) a description of the open tidal area, which is subdivided into four study segments, and (ii) a more limited description of the tidally influenced areas upstream of the major tide gates.

1.4.2.1 BCSA Study Segments

The open tidal area of the BCSA consists of waterways and tidal marshes, extending from confluences with the Hackensack River in the south to the West Riser Tide Gate (WRTG) in the north, and bounded laterally by tide gates on several tributaries as well as the transitions from tidal marshes to upland areas. Berry's Creek proper as defined here is an approximately 4 mile (mi) waterway as shown in Figure 1-3. Berry's Creek begins at the WRTG and passes through the Meadowlands and the municipalities of Rutherford, East Rutherford, Carlstadt, Wood Ridge, Moonachie, and Teterboro. Its lower extent, prior to joining the Hackensack, is the relatively straight Berry's Creek Canal (BCC) that was constructed in the early 1900s. In addition, the primary waterways include Lower Berry's Creek (LBC); a largely separate waterway that splits from Berry's Creek near the N.J. Route 3 crossing and extends in a meandering watercourse through Lyndhurst for 2.3 miles to the Hackensack River.

The primary waterways consist of relatively narrow and shallow channels. The main channel exhibits average depths as shallow as 1 to 2 feet in portions of Upper Berry's Creek (UBC) and 4 ft. in Middle Berry's Creek (MBC), with intertidal mudflats. Other than the constructed BCC, the flow paths of the primary waterways are generally meandering. Adjacent marshes have maintained their configuration with respect to the waterways (i.e., shorelines) in the past century, but their boundaries with upland areas have been altered extensively by filling and development in the area. Tide gates on upland tributaries occur at multiple locations and are primarily found in the northern portions of the Middle and Upper Berry's Creek and its tributaries (refer to Figure 1-3). Named tributaries to Berry's Creek from its headwaters to the Hackensack River include East and West Riser Ditches (passing through Teterboro Airport); Nevertouch Creek (southwest of the WRTG Area); Peach Island Creek (eastern Paterson Plank Road Area); Ackerman's Creek (across from Walden Swamp); Rutherford Ditches (north of Route 3 west of main Berry's Creek Channel) and Fish Creek (a tributary to Lower Berry's Creek in the Oritani Marsh area). In addition, there are multiple unnamed tributaries and channels within the marsh areas that influence water and sediment transport within the marsh areas.

The main tidal portion of the BCSA can be divided into four segments (Figures 1-3 and 1-4) in relation to the major waterway, associated tributaries, and marshes. The boundary between study segments is largely based on areas where the stream corridor is narrowed by past filling of the marshes to accommodate transportation (e.g. highways or rail lines). While these segments exhibit somewhat differing characteristics that relate to geomorphology, hydrology, geochemistry, past and present land use in the immediate vicinity of each segment, and profiles of constituents of potential concern (COPCs), the characteristics generally vary along a continuum and boundaries between them are not highly defined. These segments have been identified as follows:

- **Upper Berry's Creek** (UBC) stretches from the WRTG to Paterson Plank Road over a waterway distance of 1.5 mi. It is the most northern study segment and is comprised of

24.1 acres of waterways (including mudflats and subtidal areas) and 133 acres of marshes (including tidal tributaries). UBC extends along the lower portion of Peach Island Creek to the Peach Island Creek (PIC) tide gate. (Upper PIC is discussed in Section 1.4.2.2 below as one of several tidally influenced areas upstream of the major tide gates.) UBC also contains the following three named marshes:

- **Nevertouch Marsh** is located near the northern end of UBC. Nevertouch Creek traverses the marsh from east to west and the marsh is primarily bounded by the North and South Ditches to the north and south and Berry's Creek proper to the east.

- **Eight Day Swamp** is located in the southeastern portion of UBC. Lower PIC and two unnamed Berry's Creek tributaries are present within or on the periphery of the swamp. At least four tide gates are located around its periphery to regulate flow in and out of tributaries leading to the adjacent uplands.

- **Paterson Plank Marsh** is located to the west side of Berry's Creek in UBC, just north of Paterson Plank Road Bridge.

- **Middle Berry's Creek** (MBC) extends 1.6 miles in waterway distance from Paterson Plank Road to the confluence of LBC and BCC near the Route 3 Bridge crossing. It consists of 43.4 acres of waterways and 213.3 acres of marshes and their tidal tributaries. MBC also contains the following three marshes:

  - **Ackerman's Marsh** is located to the west of the main Berry's Creek channel and Walden Swamp and south of Paterson Plank Road in the MBC study segment. The marsh is bisected by Murray Hill Parkway. A portion of Ackerman's Marsh and Creek on the western side of Murray Hill Parkway is the subject of a separate RI/FS and has undergone a separate response action as part of the Universal Oil Products (UOP) Superfund Site. The portion of Ackerman's Creek and Marsh east of Murray Hill Parkway will be addressed by the BCSA RI/FS.

  - **Walden Swamp** is located to the east of the main Berry's Creek channel and west of the New Jersey Sports and Exposition Authority (NJSEA) property and occupies the eastern portion of the MBC study segment.

  - **Rutherford Marsh** is an area bordering Berry's Creek along the southern end of MBC and located west of the NJSEA.

- **Berry's Creek Canal** (BCC) is a 1.2 miles long, generally straight man-made channel constructed between 1902 and 1908 as an alternate flow path for Berry's Creek. The design was intended to direct nearly all flow away from the railway crossing to alleviate flooding damage (NJDOH, 1930). In addition, it was intended to provide increased tidal exchange with the upper portion of Berry's Creek to reduce sewage discharge problems.

BCC constitutes the primary connection of UBC and MBC to the Hackensack River. It is the deepest channel in the BCSA and has limited intertidal mudflat areas compared to the rest of Berry's Creek. It consists of 29.9 acres of waterways and 78.7 acres of marshes and their tidal tributaries. BCC contains the following single named marsh:

- **Tollgate Marsh** runs the length of the northeast bank of BCC. The marsh is bordered to the northeast by Route 3 and the interchange roadways between Route 3 and the New Jersey Turnpike (I-95). The sediment from the construction of BCC was side cast to the south side of the channel and remains a generally higher elevation than the Tollgate Marsh and Oritani Marsh to the south.

- **Lower Berry's Creek** (LBC) is a 2.3 miles long, shallow channel with expansive intertidal mudflats. It consists of 54.1 acres of waterways and 447 acres of marshes and their tidal tributaries. Water interchange with BCC and the main Berry's Creek channel is controlled by relatively small culverts in the northern portion of the LBC that traverse under regional rail lines and the former haul road to the Rutherford landfills. Prior to construction of BCC, the LBC was the natural, lower reach of Berry's Creek that connected to the Hackensack River. It begins at the natural confluence of the Hackensack River, and continues to BCC near the Route 3 bridge crossing. Drainage ditches from the north and west discharge through tide gates located near the Route 3 overpass for the Bergen County Line of the New Jersey Transit System. LBC contains two named marshes:

  - **Oritani Marsh** is a roughly triangular marsh bounded on the southeast by the NJ Turnpike (I-95), to the north-northeast by BCC, and to the southwest by New Jersey Transit rail lines. A portion of Oritani Marsh is hydraulically connected to BCC.

  - **Berry's Creek Marsh** is located in the southern portion of the BCSA; it is bounded to the south and east by Lyndhurst and Rutherford landfills and to the northeast by New Jersey Transit rail lines. A majority of Berry's Creek Marsh is located east of LBC.

For the purposes of the RI/FS, the main stem of Berry's Creek (as identified above) is referred to as UBC, MBC, and BCC, thereafter terminating at its confluence with the Hackensack River. LBC is largely a separate waterway, i.e., not part of the main stem of Berry's Creek, because the flow from and to UBC and MBC has been largely curtailed for over 100 years. The flow (in both directions) in UBC and MBC is predominantly influenced by the tidal flow through BCC rather than LBC.

A summary of the areal coverage of the waterway features is provided in Table 1-1. Altogether, major waterways (not including tributaries) in the BCSA total 6.6 miles in length.

1.4.2.2 Tidally-Influenced Areas Above Tide Gates

Tide gates are used to control flow in the waterways by closing during flood tides to prevent water from entering upstream areas and opening during ebb tides to allow upstream water to enter the downstream body of water. Generally tide gates are used to dampen tide effects associated with high tides. The tide gates within the BCSA exhibit varying degrees of functionality and maintenance. BCSA tide gates have periodically had limited functionality, most notably (i) the West Riser tide gate, which was replaced in 2014; (ii) Peach Island Creek tide gate, which was repaired in 2015; and (iii) the tide gates in the Rutherford area, which were replaced between 2007 and 2009.

Throughout the study area, but principally connected to UBC and MBC, are tidally-influenced areas above tide gate structures where backwater areas develop during high tide periods and drain through tide gates during low tide. These areas are identified and briefly described below going from north to south (Figure 1-3):

- **West Riser Ditch** begins at the WRTG and extends (for the purposes of the RI/FS) 0.5 miles up to Moonachie Avenue based on discussions with the EPA prior to the submission of the RI/FS Work Plan. It is comprised mainly of a constructed ditch ranging in width from 35 to 80 ft. with limited wetland plants along portions of its margin.

- **East Riser Ditch** is similar to West Riser Ditch. Based on discussions with the EPA prior to the submission of the RI/FS Work Plan, for the purposes of the RI/FS, the East Riser Ditch extends 1.0 miles from its confluence with Berry's Creek at the East Riser Tide Gate (ERTG) north to Moonachie.

- **Upper Peach Island Creek** (UPIC) is a tributary and marsh system located just east of UBC and above the PIC tide gate. UPIC proper is 0.7 miles in length and has 32.1 acres of associated marsh.

- The **Rutherford Ditch** system consists of a series of tributaries that are above the Rutherford Tide Gate in MBC, totaling 2.6 miles in length. Between 2008 and 2009, an extensive sediment removal from these ditches was completed for flood management by the New Jersey Meadowlands Commission under NJDEP and USACOE oversight during the BCSA RI/FS work.

1.4.2.3 Other Site Features

In addition to the waterways and marshes described above, several additional features described below contribute to the characteristics and function of the BCSA. Some of these features are historical in nature, whereas others continue to influence the system at present.

- **New Jersey Sports and Exhibition Authority Storm Water Management System:** The current largest NJDEP-permitted point discharge to Berry's Creek is the discharge of storm water from the NJSEA to Berry's Creek. The NJSEA discharge is located just north of the Route 3 Bridge. The NJSEA manages all of the storm water runoff generated within its approximately 515-acre property through a series of storm water detention ponds. Water is intermittently discharged as needed from these ponds to the main Berry's Creek channel in the southern portion of MBC. During active discharge, estimated to be approximately 18.6 million gallons per day (MGD [Geosyntec/Integral, 2012]), the NJSEA outfall causes high water velocities in the discharge area and can represent a significant portion of the freshwater base flow to the BCSA. NJSEA controls this discharge manually, and the discharge frequency varies depending on the amount of rainfall and the capacity of the storage ponds at a given time.

- **Oradell Dam:** A dam was constructed in 1923 on the Hackensack River near the town of Oradell, approximately 6.8 miles north of the BCSA to provide a source of water supply for a portion of the region. As the population in the area continued to grow, three additional reservoirs were constructed on the Hackensack River (above Oradell Dam) to meet water demands primarily outside of the watershed. Construction of the Oradell Dam had a substantial and obvious impact on the Meadowlands, including areas within the BCSA. Prior to installation of the Oradell Dam the freshwater flow of the Hackensack River was sufficient to maintain the salt water front in Newark Bay and on occasion only a few miles upstream in the Hackensack River. The dam, as well as extensive river dredging and ditching for mosquito control, changed this flow system and transformed a large portion of the Meadowlands from a freshwater lowland swamp into a brackish tidal estuary, which affected fish and plant species occupying this area. Cattails, wild rice, and other freshwater wetlands plants were replaced by the common reed *Phragmites australis (Phragmites*) by the 1940s as a direct result of the Oradell Dam construction and waterway alterations (Hackensack Riverkeeper, 2008; USFWS, 2005).

  Sewage Treatment Plants: Berry's Creek has a long history as the receiving water for untreated or minimally treated sewage. Historically six sewage treatment plants (STPs) discharged to Berry's Creek including the Rutherford STP, East Rutherford STP, Carlstadt STP, Wood Ridge STP, and Hasbrouck Heights STP (NJDOH, 1930). The Triboro STP (or "Joint Meeting") was built in 1941 to manage sewage flows from Rutherford, East Rutherford, and Carlstadt (LECG, 2008).

  Since 1991 no STPs discharge to Berry's Creek, but STPs that continue to discharge to the Hackensack River continue to affect the BCSA water quality (e.g. fecal coliform concentrations and reduced dissolved oxygen).

- **Industrial Discharges:** Historically, industrial discharges were prevalent throughout the BCSA. New Jersey Department of Environmental Protection (NJDEP) databases list 136 known contaminated sites, and large commercial facilities such as the Teterboro Airport and the NJSEA, that previously had or currently maintain permitted discharges to the BCSA. The known contaminated sites, including three Superfund Sites, typically are located in upland areas, but many have been historic sources of contamination to the tidal portion of the BCSA. Some of these discharges occurred to BCSA tributaries, entering Berry's Creek indirectly. Historically industries also indirectly discharged to Berry's Creek through STP outfalls. Most historic STPs provided only primary treatment of sewage, which would have little effect on the chemical components of these industrial waste streams, especially dissolved constituents. Discharges from most upland sources were eliminated or substantially reduced by the early 1990s.

- **Solid Waste Landfills:** The Meadowlands were significantly affected by the extensive and largely unregulated placement of solid waste in landfills throughout the area, particularly in the southern portion (LBC) of the BCSA. Figure 1-3 identifies several of the identified landfill areas within the BCSA.

- **Infrastructure Features:** Several bridge piers (Route 3 bridge, Paterson Plank Road bridge, and NJ Transit Railway spur line bridge) were installed within the BCSA during the last hundred years, thereby altering the local water flow pattern and sediment dynamics.

1.4.3 Physical Characteristics

1.4.3.1 Hydrology, Hydrodynamics, and Sediment Dynamics

The BCSA is a side embayment of the Hackensack River estuary with tidally-influenced waterways/tributaries, large *Phragmites* marshes, and freshwater tributaries and wetlands. The flow in the tidal portion of the BCSA is dominated by the semidiurnal tidal flux with an average tidal range of 5.6 ft. (1.7 m). Freshwater inputs (i.e., surface water) make up a small percentage of the overall flow, except during major precipitation events (greater than 3 inches in 24 hours) when the percentage of surface water runoff can increase notably. As discussed in Section 1.4.3.2, groundwater discharge does not represent a significant input to the BCSA. A large volume of water is lost from the system via evapotranspiration during the growing season, which increases the salinity in the system.

Efficient exchange of surface water from BCC and LBC with the Hackensack River occurs on each tidal cycle. The magnitude and frequency of surface water exchange from MBC and UBC with the Hackensack River decreases from south to the north. Surface water exchange between UBC/MBC and the Hackensack River increases with spring tides and precipitation events (refer to Section 2.2.1.8 of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012).

The tidally dominated nature of the BCSA has a significant influence on the overall physical, chemical, and biological characteristics of the BCSA. Conditions such as water depth, water chemistry (e.g., salinity, oxygen content, COPC concentrations, temperature), sediment biogeochemistry (e.g., redox conditions, aerobic/anaerobic conditions, mercury methylation/demethylation dynamics), and biological conditions (e.g., fish movement, plankton transport, etc.) all are affected by tidal action and sometimes vary widely with tide stage. Tidal action also affects physical access to portions of the BCSA and will have a substantial influence on implementation of remedial actions.

Sediments accumulated in the BCSA are derived from upland, estuarine, and autochthonous sources. Rates of accumulation vary spatially and temporally depending on geographic location, marsh versus waterway, sea level rise relative to marsh surface elevation changes, and morphologic feature. Resuspension and deposition associated with high-energy storm events can cause localized increases or decreases in sediment bed elevations. The majority of waterway areas exhibit patterns of deposition and/or natural recovery; however, in some locations (e.g., tributary confluences, NJSEA stormwater inlet, deep waterway channels), the deposition processes are episodic in nature or limited.

Overall, the system is a net depositional estuarine environment. The waterways are generally the primary source of sediment to the marshes with a net flux of sediment from the waterways to the marshes during tidal inundation. Physical data reflecting the historical record indicate that the BCSA will remain net depositional in the absence of a substantial (i.e., regional scale) system modification.

The sediment dynamics within the BCSA consist mainly of sediment accretion. The marshes and waterways are stable at the geomorphological level despite localized changes in the geomorphology. Analysis of aerial photos from 1931 to 2013, including pre- and post-Hurricane Irene, indicate essentially stable conditions with minor localized changes in waterway, marsh tributary, and marsh outlines, except as caused by deliberate anthropogenic actions (e.g., filling, channel straightening, tide gate installation). Comparison of bathymetric survey measurements from 2008 and 2014 (pre- and post-Hurricanes Irene and Sandy) indicate some localized erosional zones; however, most of the area appeared unchanged within the resolution of the survey. High resolution coring indicates that reworking and redistribution of sediments in waterways is influenced by a combination of hydrodynamics, wave action, limited bioturbation, and larger discharges of upland storm water, and does not show evidence of large changes associated with large storm events. The vertical extent of the reworking and redistribution is often confined to the top few inches, while at certain locations reworking extends deeper. Storms, including hurricanes, have little to no effect on the marshes, as evident from surface elevation measurements and 2014 high-resolution cores from marshes.

BCSA is subject to two types of storm events with different impacts and characteristics: tidally-driven storm surges (e.g., Hurricane Sandy, nor’easters) and upland rainfall/precipitation-driven summer storms (e.g., Hurricane Irene and Tropical Storm Lee). *Phragmites* marshes provide resilience that mitigates the impacts of these storm events. The *Phragmites* marshes absorb the energy of storm surges, reduce the potential for and degree of flooding, and provide reinforcement to marsh bank integrity to minimize bank erosion losses.

1.4.3.2 Hydrogeology

The BCSA lies within the Newark Basin and contains sedimentary sandstone and shale bedrock of the Passaic Formation. The deposits overlying the bedrock in much of the BCSA are from glacial episodes of the Pleistocene Epoch. The Pleistocene glacial deposits consist primarily of varved clays that are characteristically low permeability materials. The varved clays represent the cyclic deposits of material from the annual freezing and thawing of the Wisconsin ice sheet to Glacial Lake Hackensack. The varved clay deposits are overlain by consolidated alluvial materials composed of varying proportions of sand, silt, and clay and Holocene Epoch salt marsh and estuarine deposits. As a result of the low permeability clays and marsh deposits (i.e. meadow mat), there is very limited exchange between shallow subsurface flow in the surface deposits within the tidal zone and groundwater occurring in the bedrock. As a result, perched water and interflow (the lateral movement of water along the vadose zone interface) may provide relatively limited inputs to surface water of the BCSA, but groundwater flow from deeper units does not provide any meaningful contribution to the BCSA water budget. Within the tidal areas, exchange between marshes and waterways via interflow remains under investigation.

Surface water from the Passaic River Basin is the source of potable water in the BCSA. Due in part to regional groundwater contamination issues and saltwater intrusion to groundwater, the Meadowlands are currently not a source of potable water (CDM, 1998).

1.4.4 Characteristics of Chemical and Other Stressors to the BCSA

The Phase 2 Site Characterization Report (Geosyntec/Integral, 2012) contains the most recent detailed discussion of the findings of the RI. Although RI activities continue to add information, the distribution of the major stressors is well understood as a result of comprehensive data collection through the RI, including a wide range of spatial and temporal conditions. Stressor characterization in the RI is focused on understanding the biouptake processes and risks posed by site-related chemical stressors, especially at potential exposure points (e.g., contact with surface water and the top few inches of sediment). Primary COPCs include but are not limited to mercury, methyl mercury, target analyte metals (TAL) metals, and polychlorinated biphenyls (PCBs).

The magnitude, distribution, and effects of conventional water quality stressors are also being examined. Dissolved oxygen depression, elevated summer temperatures, nutrient loading, ammonia concentrations in sediment, and strongly shifting salinity gradients are being concurrently evaluated with COPC data to characterize how CERCLA and non-CERCLA stressors are interrelated and jointly influence habitat qualities, aquatic community composition, and ecosystem dynamics.

As part of the RI data analysis, the stressor distribution was evaluated in an integrated manner. Important observations include the following.

- Current sources of COPCs to the waters and surface sediments are upland runoff, the Hackensack River, and redistribution from areas within the BCSA tidal system.

- COPC concentrations in sediments generally decrease from upstream (north: UBC) to downstream (south: LBC and BCC) and from depth to surface in sediment. An exception is methyl mercury in waterway sediment, which differs because of biogeochemical factors and controls that tend to favor microbial production of methyl mercury in surface sediment.

- Surface sediment COPC concentrations are closely correlated with COPC concentrations in suspended sediments in the waterways.

- At the system segment scale (i.e., UBC, MBC, BCC, and LBC) there are measurable, observable differences in COPC patterns in surface water, sediment, and biota.

- Higher COPC (i.e., mercury, methyl mercury, PCBs, cadmium, chromium, manganese, and zinc) concentrations generally occur in the northern study segments of the BCSA tidal zone, with some localized areas of peak concentrations in UBC, Upper Peach Island Creek (UPIC), and parts of MBC (refer to Section 2.3.4 of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012).

- COPC concentrations in sediment and surface water downstream of the Route 3 bridge crossing (BCC and LBC) are generally similar to concentrations in the project reference areas and urban background concentrations measured throughout the Newark Bay system. Site-related COPC concentrations north of the Route 3 bridge crossing (UBC and MBC) typically exceed reference and regional background concentrations (refer to Section 2.3.8 of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012).

- Most COPCs are associated with solid particles and are largely retained in the BCSA due to net depositional conditions. Movement of suspended solids into the marshes far exceeds movement out of the marshes.

The chemical characteristics of COPCs and important processes that govern COPC distribution vary throughout the system. This results in varying potential risks throughout the BCSA. Therefore the types of remedial alternatives that would be most applicable also vary and a single technology may not be suitable for the entire BCSA. For this reason, the following discussion addresses the COPC characteristics and distribution related to specific geomorphological areas (waterways as subtidal areas and intertidal mudflats, and marshes) and specific processes (waterway–marsh exchange and natural recovery).

1.4.4.1 Waterways

The highest concentrations of COPCs (except for methyl mercury) in waterway sediments most frequently occur at depth with progressively cleaner sediment overlying the more contaminated sediments. The concentrations typically reach a peak and then tend to decrease again at deeper intervals. The depth to the peak concentrations varies by waterway reach, specific COPC, and local conditions. Exceptions (where surface concentrations were higher than deeper sediments) were noted in some waterway locations; these can likely be attributed to localized resuspension/deposition, temporally variable sediment inputs from elsewhere in the system, and the relationship between COPC concentrations in one location compared to elsewhere in its vicinity. The waterway sediments show considerably more variability in COPC concentrations horizontally and vertically than the marshes, which generally do not display evidence of localized resuspension and deposition. (Refer to Section 2.2.2.3 of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012).

The patterns and strength of natural recovery in marshes supports the conclusion that the primary (upland) sources of COPCs to the waterways have been nearly eliminated as compared with historical loadings.

1.4.4.2 Marshes

The highest concentrations of COPCs in marsh sediments most frequently occur at depth, with progressively cleaner sediment overlying the more contaminated sediments. COPCs are transported to the marsh via the waterways. Concentrations of COPCs in surface water have decreased over time after sources were removed reducing the load of COPCs to the marshes. The Hackensack River is a dominant source of lower concentration sediments that are facilitating natural recovery within the BCSA.

Marsh surface sediment COPC concentrations are typically lower than in adjacent waterways with the exception of a portion of the UPIC marsh which has been isolated from tidal exchange with the main channel since the late 1960s. Consequently inflow of cleaner sediment has not reached this marsh area (refer to Section 2.3.4 of the Phase Site Characterization Report; Geosyntec/Integral, 2012).

The highest concentrations of marsh COPCs are in the deeper sediments, with 3 to 4 in. of progressively cleaner sediment overlying more contaminated sediments, except for the portion of UPIC marshes above the tide gate where the peak concentrations are shallower. Consistent patterns of COPC recovery are observed across marsh locations. This is the result of ongoing burial by less contaminated solids carried in with runoff or tides from the uplands throughout the BCSA or from the Hackensack River. The rate of this burial is influenced by several factors but is approximately equal to sea level rise, indicating that continued future recovery is likely (refer to Section 2.3.4 of the Phase Site Characterization Report; Geosyntec/Integral, 2012).

1.4.4.3 Waterway–Marsh Exchange

The majority of COPC mass in the surface water column is associated with suspended particulates. Surface water COPC concentrations are primarily related to resuspension of high organic matter surface sediment from the sediment bed. Under most conditions these processes are tidally-dependent and result in considerable temporal and spatial variability in surface water COPC concentrations that are correlated with water velocities (refer to Section 3.2 of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012). Suspended solids in waterways are carried into the marshes during flood tides and most deposit in the marsh (refer to Section 2.3.7 of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012).

Large particulate organic matter produced in the marshes is periodically transported out of the marshes and into the waterways, primarily as coarse particulate organic matter (comprised of stalks and leaves of recently senesced *Phragmites* material). Concentrations of COPCs in the large particulate organic matter is over 10 times lower in concentration than in the marsh surface sediments, indicating a low rate of plant uptake and translocation into the stalks and leaves.

Multiple lines of evidence confirm that suspended solids and associated particulate COPCs are imported from the waterways to the marshes. In general, the dissolved fraction of COPCs in the water column is low. Mercury is most strongly associated with particulate material, with 92% of the total mercury concentration adsorbed on particulate matter and only 8% in dissolved form. Methyl mercury, PCBs, and other TAL metals are principally associated with particulate matter as well (70 to 90%). Manganese is the exception, with greater than 90% of the total concentration present in the dissolved phase.

Methyl mercury is generated in sediments and exhibits dynamics that are somewhat different than other COPCs, since methylation is a biogeochemical process influenced by several geochemical factors (e.g., redox condition, sulfate and sulfide relationship, salinity). Methyl mercury production in the BCSA, based on surface water and sediment concentrations, is low relative to the concentrations of total mercury when compared to other sites with mercury contamination in aquatic systems. This is largely due to the low bioavailability of inorganic mercury in the BCSA resulting from site-specific geochemical controls and enhanced demethylation (Schaefer et al., 2004; Appendix D of the Phase 2 Site Characterization Report; Geosyntec/Integral, 2012). It is not anticipated that these site-specific controls would change under foreseeable future conditions.

Methyl mercury is produced primarily in the sulfate-reducing zone of the waterway and marsh sediments. Geochemical controls on methylation, combined with demethylation processes that occur in both sediment and surface water, result in a flatter concentration gradient in methyl mercury concentrations than is measured for total mercury. Analysis of multiple lines of evidence related methyl mercury in surface water supports that production of methyl mercury in waterway sediments may be a more meaningful source of methyl mercury to surface water than marshes.

For example, voltammetric redox profiling performed in BCSA waterway and marsh locations indicates that the transition to sulfate-reducing (anoxic) conditions is shallower in waterways than in marshes. Such proximity would facilitate greater exchange between sediment and surface water than in marshes where optimum conditions for methylation are deeper in the sediment profile.

Furthermore, optical water quality monitoring data from 2014 indicate that particulate COPCs are transported into the marsh and fluxes of dissolved COPCs from the marsh to the waterway account for a very small proportion of waterway surface water concentrations. These data will be further evaluated in conjunction with data from the additional optical water quality monitoring that is being conducted in fall 2015 to further characterize the waterway methyl mercury dynamics and its relation to the methyl mercury in the marshes.

1.4.4.4 Natural Recovery

The net sediment deposition observed in the BCSA is typical in fringing marsh systems (Fagherazzi et al., 2013). Sediment-accumulating conditions are documented throughout most of the study area, with localized exceptions (e.g., concentrated upland discharge locations, many of the tidal tributaries, and deep waterway pools), resulting in generally decreasing COPC concentrations in surface sediments over time.

Given the COPC concentrations and the sediment reworking, redistribution, and deposition rates, it is estimated that natural recovery of surface sediment in UBC and MBC would probably take an extended period of time to reach regional background conditions in both waterways and marshes. The fate and transport analysis, including the sediment transport model currently being developed, will provide a more definitive understanding of sediment accumulation dynamics throughout the BCSA.

Despite temporal variations and influences from low frequency high energy events (i.e., increased water velocity), the overall surface water COPC gradient is consistent with the COPC gradient observed for the sediment (except for methyl mercury) and in large part correlates with the total suspended solids, which indicates the COPC association with particulates. Thus, even absent any remedial activities, with continued declining sediment COPC concentrations, surface water concentrations would also decrease with time.

1.4.5 Human Use and Ecological Setting

1.4.5.1 Land Management, Planning, and Human Population and Use

Development within the BCSA began in the mid-1800s with initial development focused on upland areas and areas adjacent to existing roads. Development within the BCSA continued to increase over time with industrial and commercial development becoming more prevalent. These industries consisted primarily of heavy manufacturing with storage tanks and chemical processing facilities. By the late 1960s, the pattern of heavy industrial use began to move toward light assembly and manufacturing and more warehousing and distribution, though some heavy industry remains in parts of the Meadowlands District (NJMC, 2004). The dominant industry in the BCSA is manufacturing with a total of 9,332 business establishments (New Jersey Meadowlands Regional Chamber [NJMRC], 2007).

Residential land use in the vicinity of the tidally-influenced portion of the BCSA is limited and is expected to remain limited. The area is highly developed and little land is available for future residential development. Federal, State, municipal and Meadowlands wetlands protection and land use and zoning requirements generally limit potential future residential development within the tidally-influenced portion of the BCSA.

The primary human receptor group under current conditions is recreational users. As part of the RI field efforts, observations (direct and with on-site cameras) of human use are being compiled. Information collected includes type and location of activity. To help mitigate current regional risk from fish and crab consumption, updated signs (approved by NJDEP) stating the regional Newark Bay crabbing and fishing restrictions were posted throughout the BCSA in 2011 and have been maintained on an annual basis.

Human use and activity in the marshes is limited due to access difficulties associated with the dense vegetation, frequently flooded marshes, high density of industrial/commercial development around the perimeter, and soft mud substrate in waterways and tributaries. Boating on the waterways in UBC and LBC is hindered by low water, low bridges, and tidally-exposed mudflats such that it is infrequent and typically occurs in the area closest to the Hackensack River.

1.4.5.2 Ecological Resources

The BCSA is an urban ecosystem of highly developed (approximately 90%) land within the Meadowlands (NJMC, 2006). Wetlands and open water within Berry’s Creek and its associated waterways constitute the principal ecological habitats of the BCSA. Within this urban landscape, a variety of factors influence the current condition of the ecological community within the BCSA wetlands and waterways. Habitat loss, altered hydrology, urban runoff, industrial discharges, landfill and sewage discharge, and nutrient inputs, are common characteristics of urban watersheds in general and of the BCSA. A large body of scientific literature has shown that these collective factors, together with variable salinity, have an important effect on the overall composition and character of the ecology of receiving waters. Research has repeatedly demonstrated declines in assemblage richness, diversity, and biotic integrity with increasing urbanization (Walsh et al., 2005; Meyer et al., 2005).

Biota community surveys (e.g., marsh and waterway invertebrates, fish) conducted in Phase 1 and 2 remedial investigations provided information for identification of potential ecological receptors in the BCSA. The RI also included functions and values analysis of the marshes. These studies indicate:

- With the exception of UPIC marsh above the PIC tide gate, *Phragmites* is the dominant vegetation throughout the BCSA and Hackensack River Estuary. The dominance of *Phragmites* within the system is due to past physical disturbances and salinity increases (from freshwater to brackish) related to urbanization and hydrologic modifications (e.g. dams) that changed salinity profiles throughout the complex. Greater species diversity is observed along waterways, marsh pools, and boundaries between the tidal area and uplands, as well the backwater areas above tide gates. A vegetation survey of the BCSA is being conducted in 2015 and will be incorporated into the RI Report.

- Marsh invertebrate communities are similar throughout with any differences likely the result of increasing salinity from north to south.

- A diversified avian community is observed in the marshes and marsh edges within waterways and uplands.

- In the waterways, mummichog, white perch, and mudflat invertebrates (e.g., annelids, grass shrimp, polychaetes, and fiddler crabs) are the key ecological receptors. Blue crabs and other species are more variably distributed geographically and present in the BCSA for only short periods of time.

- Wading birds are also key ecological receptors that consume mudflat invertebrates and small fish, primarily mummichog, which occur around mudflats.

1.4.6 Management Considerations

Successful management of the BCSA will require consideration of several primary factors and constraints during the remedial planning process. These include but are not limited to the following:

- The marshes in the BCSA currently provide valuable physical, chemical, and biological functions and services that must be taken into account in the short-term and long-term effectiveness analyses. The *Phragmites* marshes provide resiliency to mitigate storm impacts, reduce flood intensity, and provide stability to much of the system. Remedial actions, depending on the magnitude, type, and extent, would have larger deleterious impacts in marshes than in waterways. Marshes will take longer to re-establish and recover to pre-remedial values than will waterways, and are sensitive to potential elevation changes in relation to the tidal range. The NJMC Master Plan (NJMC, 2004) includes as objectives the maintenance of the wetlands habitat and the management of recreational use consistent with this habitat.

- The range of site conditions (i.e., morphological features, COPC concentrations, type of receptors) supports application of a range of technologies to areas of the BCSA where risk reduction is warranted. The remedial action will need to be sequenced and managed to optimize positive outcomes and reduce adverse impacts (net benefits) while remedial action progresses from north to south and from waterways to marshes, adaptively.

In recognition of the large size of the BCSA, the multiple current and past sources of stressors, and likelihood of a long period of remedy implementation and monitoring, the Statement of Work for the BCSA AOC calls for the consideration of an ASM approach to the remedy. This is consistent with EPA's Contaminated Sediment Remediation Guidance (EPA, 2005) that recommends the application of ASM at complex sediment sites to provide additional certainty and information to support decisions.

The BCSA will require system-wide analysis to consider the interaction of waterways and marshes, and the interconnection of these features throughout the BCSA system. Management decisions for one component of the BCSA will require consideration of the effects on other system components. For this reason, the complexity of BCSA features such as hydrodynamics, sediment transport, interrelationships between waterway reaches, and marsh-waterway interactions also supports an ASM approach for the remedial actions.

ASM would facilitate a remedial approach that allows the remedial process to be effectively sequenced and tailored to the BCSA conditions. The effectiveness of initial remedial measures would be monitored and to evaluate progress toward the RAOs. As necessary, adaptive components of the remedy would be optimized and implemented to improve remedial effectiveness while reducing potential negative outcomes. For example, initial remedial measures conducted in a waterway or portion of the BCSA may be sufficient to not only reduce risks within the remediated area, but may be sufficient to facilitate and encourage natural recovery of other areas by managing potential sources for COPC redistribution. Adaptively managing the remedial actions would optimize the remedial measures while avoiding disturbances and other potential negative consequences associated with remedial components that are determined not to be necessary or that can be optimized.

This DSRAM was developed in recognition that ASM may be incorporated into the remedial action. However, since the scope of this DSRAM focuses on broad geomorphic areas rather than specific areas within the BCSA, specific consideration of potential adaptive components and sequencing of the remedy will be considered in the Detailed Alternatives Analysis that is the next step in the FS process.

SECTION 2

PRELIMINARY REMEDIAL ACTION OBJECTIVES

2.1 Introduction

Remedial action objectives establish the goals for remedial actions in order to protect human health and the environment. The objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited. Preliminary RAOs were presented in the CTM with information gained from the RI activities.

The preliminary RAOs were developed with the following considerations.

1. COPCs – based on current understanding of the chemical and biological systems and specifically ecological risk from the remedial investigation field efforts.

2. Media of concern – based on current understanding from the remedial investigation field efforts.

3. Potential exposure pathways – based on the conceptual site models (CSMs) as presented in the Phase 2 Site Characterization Report (Geosyntec/Integral, 2012) and further refined from the remedial investigation field efforts.

4. Physical setting of the BCSA and future plans for the Meadowlands District.

5. Incorporation of adaptive site management (ASM) principles consistent with the EPA's Contaminated Sediment Guidance (EPA, 2005).

Preliminary RAOs for the BCSA are summarized below. They will be re-evaluated and revised following the completion of the RI and baseline risk assessments, and more specificity will be added.

2.2 Human Health RAOs

1. Mitigate unacceptable risks from direct contact with and incidental ingestion of COPCs[1] in surface water by reducing the frequency of exceedances of relevant surface water standards or concentrations developed through site-specific risk assessment.[2]

2. Mitigate unacceptable risks from direct contact with and incidental ingestion of COPCs in sediment, based on site-specific risk assessment.

[1] The COPCs referred to in this section are COPCs resulting from releases from upland sites within the BCSA.
[2] RAOs should take into account region-specific background concentrations of COPCs.

3. Mitigate unacceptable risks related to recreational fishing and the ingestion of COPCs in fish and crabs, based on site-specific risk assessment.

2.3 Ecological RAOs

1. Mitigate unacceptable risks to populations of ecologically relevant receptors from bioaccumulative COPCs in surface water by reducing the frequency of exceedances of relevant surface water standards or concentrations developed through site-specific risk assessment.

2. Mitigate unacceptable risks to populations of ecologically relevant receptors from COPCs that accumulate in those receptors through ingestion of prey in the food chain.

3. Maintain or improve, if needed, the biological integrity[3] of the aquatic community and marsh plant community that may be demonstrated to be adversely affected by the COPCs, based on the range of community-based metrics measured in reference areas not impacted by the COPCs.

[3] Biological integrity takes into account physical and chemical stressors associated with the regional urban conditions predominant in the BCSA and adjacent waterways.

SECTION 3

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND INFORMATION TO BE CONSIDERED

3.1 Applicable or Relevant and Appropriate Requirements

Section 121(d)(2)(A) of CERCLA requires remedial actions meet federal or state standards, requirements, criteria, or limitations of other environmental laws that are determined to be ARARs (EPA, 1988). The ARARs are used in evaluating implementability and effectiveness of identified remedial alternatives, more so in the detailed evaluation of alternatives but in general for the current screening effort.

ARARs are identified in three categories: location specific ARARs, action specific ARARs, and chemical-specific ARARs. The identified ARARs, which are consistent with ARARs identified at other Region 2 sediment sites, are presented in Tables 3-1 to 3-3.

3.2 Elements To Be Considered

Elements “to be considered,” or TBCs, are non-promulgated criteria, advisories, guidance, and proposed standards issued by federal or state governments. TBCs are not potential ARARs because they are neither promulgated nor enforceable, although it may be appropriate to consult TBCs to interpret ARARs or to evaluate preliminary remediation goals when ARARs do not exist or may not be sufficiently protective. Compliance with TBCs is not mandatory. The identified TBCs are included in Tables 3-1 to 3-3.

SECTION 4

GENERAL RESPONSE ACTIONS

General response actions (GRAs) for the BCSA were initially identified in the CTM. The GRAs are based on EPA's Contaminated Sediment Guidance (EPA, 2005) modified to account for BCSA-specific factors.

The GRAs carried forward from the CTM are listed and described in Table 4-1. This list has been revised since the CTM based on additional information from the RI effort that has informed remediation needs in the BCSA.

The GRAs included in the CTM were as follows:

- No action/institutional controls
- Monitored natural recovery (MNR)
- Thin-layer placement
- Hydraulic/hydrologic controls
- Containment (capping)
- Removal
- Consolidation and disposal
- In-situ treatment
- Ex-situ treatment

For the development and screening of remedial alternatives, the GRAs were modified based on the following considerations:

- No action and institutional controls were considered as separate GRAs as they are sufficiently distinct to be considered separately.
- Thin-layer placement, thin-layer placement with amendments, and in situ treatment (in situ amendment addition), were included as alternatives under enhanced MNR (EMNR). These approaches are methods to expedite the ongoing natural recovery of the system.
- Consolidation and disposal were not included as a separate GRA as they would be part of all potential removal actions. Also, as the evaluation in the development and screening of

remedial alternatives is not specific to particular waterway reaches or marsh subareas, quantities of material to be addressed were not calculated; thus, sediment management options are not specifically evaluated. Both on-site consolidation and off-site disposal of removed sediment will be considered in the (future) detailed evaluation of alternatives. Although not included as a GRA, a general concept for dredge material transportation and management is presented in Section 5.

- Ex-situ treatment was removed as a GRA because the CTM envisioned these technologies (dewatering and stabilization) as methods to treat the sediment to make it suitable for disposal. As such, ex-situ treatment is not a stand-alone GRA, but would be evaluated as part of removal and dredge material management alternatives.

The refined GRAs considered in the alternative development and screening evaluation are listed below.

- No action
- Institutional controls
- Monitored Natural Recovery
- Enhanced Monitored Natural Recovery
- Containment (capping)
- Removal

SECTION 5

REMEDIAL ALTERNATIVES DEVELOPMENT

5.1 Introduction

EPA's RI/FS Guidance states that the primary objective of the remedial alternative development and screening phase of the FS is to develop an appropriate range of options that will be analyzed more fully in the detailed analysis phase (EPA, 1988).

A set of potential remedial alternatives was developed for the BCSA using the technologies considered in the CTM as a starting point. Remedial alternatives were developed with the objective of achieving the RAOs provided in Section 2. In accordance with EPA guidance (EPA, 2005), adaptive management approaches were considered.

Considering the range of conditions within the BCSA, a single remedial approach is not appropriate for the entire BCSA; rather, the alternatives would be applied by subareas within the system. Because the RI data collection, evaluation, and risk assessment activities are ongoing, it is premature to develop and evaluate alternatives for specific areas within the BCSA. The current list of alternatives was developed with consideration of the range of physical and ecological conditions present within the BCSA so that they could be evaluated for their relative effectiveness, implementability, and cost in addressing various combinations of key site conditions.

Alternatives for particular waterway and marsh subareas or Sediment Management Units (SMUs) within the BCSA will be developed and evaluated in the detailed alternatives analysis after Site characterization and risk assessments have been completed.

An additional consideration was the potential integration of Green and Sustainable Remediation (GSR) strategies into the remedial alternatives (EPA, 2010; Interstate Technology and Regulatory Council [ITRC], 2011; National Research Council [NRC], 2011, 2014; Naval Facilities Engineering Command [NAVFAC], 2012a, 2012b; US Army Corps of Engineers [USACE], 2012, American Society for Testing and Materials [ASTM], 2013.). GSR incorporates site-specific use of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while supporting strategies that are cognizant of balancing community goals, economic impacts, and environmental effects. GSR will be considered in detail in the detailed alternatives analysis.

5.2 Identified Remedial Alternatives

Identified remedial alternatives for waterways and marshes are listed by GRA in Table 5-1 and are described in Table 5-2 and Table 5-3 for waterways and marshes respectively. Additional description of the alternatives is provided below. The alternatives may apply to either waterways or marshes; therefore, a single description is provided for each alternative. Where applicable, likely variations are described that may be necessary for application to a waterway or a marsh.

5.2.1 Alternative 1 – No Action

CERCLA regulations require including the No Action alternative, which consists of taking no specific remedial action and allowing the system to continue to recover naturally. The No Action alternative does not include institutional controls (ICs) to protect human health nor does it include monitoring of the recovery progress.

5.2.2 Alternative 2 – Institutional Controls (ICs) (alone)

The Institutional Controls alternative allows the system to recover through natural processes, but also implements or continues ICs such as fishing bans or advisories and access or deed restrictions (including restrictions on disturbances) to protect human health. It also includes maintenance of the signage (posted during the RI) and related notices to the public for the regional fish advisories. The alternative does not include monitoring the natural recovery progress.

ICs are consistent with the ASM principles and approach with restrictions changing over time as the system improves and risk decreases. Institutional controls are also considered to be a necessary component of Alternatives 3 through 10.

Examples of ICs that could be applied include the following measures.

Waterways

- **Fish consumption advisories** - Advisories on the frequency of consumption of fish, from no consumption to a limit of the number of fish to be consumed over a stipulated time period. There are currently fish consumption advisories for blue crab and several fish species on the waterways within the Newark Bay Complex including Berry’s Creek.

- **Waterway use restrictions** - Regulatory restrictions on the use of the waterways including no swimming, no fishing, and controls on disturbances such as filling and dredging.

Marshes

- **Property use restrictions** - Property use restrictions would pertain to the tidal emergent marsh areas. Use restrictions would reduce human activity and disturbance in the marsh areas. There is already limited human use in the marsh areas due to dense *Phragmites* growth, frequent inundation, isolation, frequent barriers to entry (such as perimeter ditches and lack of surface roads), and soft ground. Regulatory restrictions on marsh disturbance and filling would minimize human disturbance, except for situations where the disturbance is controlled and associated risks mitigated. Property use restrictions in the marshes are consistent with the NJMC Master Plan goal of maintaining and protecting wetlands (NJMC, 2004).

- **Property access restrictions** - Restrictions to prevent access to or disturbance of affected BCSA marsh areas could be implemented through signage, and may include deed restrictions.

5.2.3 Alternative 3 – Monitored Natural Recovery + ICs

EPA (EPA, 2005) states that MNR is:

> *"…a remedy for contaminated sediment that typically uses ongoing, natural processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediments."*

EPA also notes that MNR is often combined with other remedial actions such as removal or capping.

The U.S. Department of Defense (DoD) Environmental Security Technology Certification Program (ESTCP) Technical Guide–Monitored Natural Recovery at Contaminated Sediment Sites (ESTCP, 2009a) cites the NRC in defining MNR as:

> *"…a practice that "relies on un-enhanced natural processes to protect human and environmental receptors from unacceptable exposures to contaminants." The successful implementation of MNR depends on the following conditions: 1) Natural recovery processes are transforming, immobilizing, isolating, or removing chemical contaminants in sediments to levels that achieve acceptable risk reduction within an acceptable time period, and 2) Source control has been achieved or sources are sufficiently minimized such that these natural recovery processes can be effective. This condition is common to all sediment remedies but particularly to MNR because slow rates of recovery could be outpaced by ongoing releases."*

Implementation of MNR includes assessment of site conditions to evaluate if requisite conditions exist. The RI findings indicate that the system is stable and that ongoing natural recovery is occurring in BCSA waterways and marshes. The pattern of natural recovery in the marshes supports that the primary sources of COPCs to the waterways have been nearly eliminated as compared with historical loadings. Areas within the BCSA waterways and marshes where there is ongoing sediment deposition are potential candidates for MNR depending on risk factors; isolation by continued deposition of clean sediment is the primary natural recovery mechanism in the BCSA. The detailed assessment of MNR would also include evaluation of anticipated rates of recovery; the rate of recovery is expected to vary depending on baseline conditions and subarea-specific hydrodynamics. MNR is not dependent on accessibility to the target waterway reach or marsh area, as access for monitoring is possible throughout the BCSA. MNR would not adversely impact habitat or potentially destabilize areas (particularly marsh areas).

Monitored natural recovery could be implemented as part of an adaptive management approach through performance monitoring to assess if the recovery is progressing as predicted. Additional remedial measures would be considered to enhance natural recovery if the area is not recovering sufficiently.

The relative risk and rate of recovery are key considerations in application of MNR. Subareas of the BCSA with highly elevated COPC concentrations at the sediment surface may not be candidates for MNR as the time to recovery may be much longer than for other alternatives. These areas may also be a source to other media and areas through resuspension of impacted sediment and thus hinder the natural recovery of nearby areas.

Alternative 3 includes the implementation of ICs, since MNR requires time to meet remedial objectives and contamination may be left in place with this alternative.

Monitored natural recovery is a component of other remedial alternatives such as thin-layer placement, amendment addition, or contaminated sediment removal.

5.2.4 Enhanced Monitored Natural Recovery Alternatives (Alternatives 4 – 6)

Alternatives 4, 5, and 6 are EMNR alternatives. EMNR is a hybrid remedy that relies on the combined effect of natural recovery and engineering measures to accelerate the recovery process (EPA, 2005; ESTCP, 2009b). EMNR alternatives identified for the BCSA include the use of directly applied amendments (Alternative 4), placement of thin layers of new clean sediment or sand (Alternative 5), or thin layers of new clean sediment or sand with amendments (Alternative 6). As with MNR, EMNR alternatives employ measures to provide immediate risk reductions or accelerate the natural attenuation process and build on the ongoing natural recovery of the targeted area to reduce risk in a manner that is not disruptive of habitat or the stability of the waterway or marsh.

Since RI findings indicate ongoing natural recovery of the BCSA, EMNR, like MNR, should be considered in developing a remedial strategy.

The following applies to EMNR Alternatives 4 through 6.

- Evaluation of EMNR includes quantifying the immediate benefits and projecting the rates of accelerated recovery and using monitoring to confirm the recovery is progressing as predicted.

- EMNR is best suited for stable areas and areas with ongoing natural recovery. Evaluating the target area's stability is particularly germane for the waterways since the waterway stability is more variable than the highly stable marshes.

- Because it does not remove existing materials, EMNR has less potential to adversely impact habitat or destabilize areas than more aggressive remedial alternatives.

- EMNR alternatives are less dependent on accessibility to the target waterway reach or marsh area, because they involve less movement of materials or use of heavy equipment compared to more aggressive remedial alternatives. However, materials and equipment would still need to be transported to and from the work areas.

- An EMNR alternative could be implemented in an adaptive management approach including implementation of additional measures if monitoring indicates slower recovery rates than predicted. The monitoring periods would be established with EPA; it is anticipated the standard remedy review periods would form the basis for decision-making on the ability of the remedy as implemented to achieve RAOs.

- ICs would be used to protect human health during the recovery period.

- EMNR alternatives are often more favorable from a GSR standpoint. The net benefits can be higher with MNR and EMNR alternatives where relative risks of COPCs are somewhat lower. The analysis of alternatives relative to GSR metrics would be included in the detailed alternatives analysis.

5.2.4.1 Alternative 4 – Direct Application of Treatment Amendments + MNR + ICs

Alternative 4 involves the direct application of amendments to mitigate risk. A primary exposure pathway in the BCSA involves bioaccumulation by benthic infauna and subsequent transfer into the aquatic food web. Direct incorporation of amendments in surface sediment can reduce bioavailability and flux of COPCs through pore water exchange. Amendments would be spread on the surface of the sediment and mixed through natural processes (i.e., resuspension/deposition bioturbation) or active mixing into the surface sediment. The intent in direct application is to change the native sediment geochemistry to reduce contaminant bioavailability without creating a new surface layer or cap (EPA, 2013).

BCSA treatability and pilot studies have shown that amendments can successfully sequester COPCs (particularly PCBs although mercury sequestration has also been documented). Amendments evaluated as part of laboratory treatability studies and in ongoing field pilot studies include: (1) adsorption based amendments such as activated carbon and Organoclay-MRM, and (2) amendments that manipulate geochemical conditions to limit mercury methylation, such as zero-valent iron (ZVI). Data collection related to the pilot studies is ongoing, and pilot study data will be considered during the detailed evaluation of alternatives.

In Alternative 4, direct application of amendments is combined with MNR and ICs. As an EMNR technology, the amendment addition is designed to enhance ongoing natural recovery and shorten the recovery period. ICs are required to mitigate potential exposure to human health risks during the recovery period.

Incorporation of in-situ amendments in the biologically active zone (BAZ) could be considered in an adaptive management approach. Risk reduction from the remedy would be monitored and adjustments, including potentially reapplication, would be made as necessary.

5.2.4.2 Alternative 5 – Thin-layer Placement + MNR + ICs

Thin-layer placement of sand or finer-grained materials is employed to enhance ongoing natural recovery processes and reduce impacts to the environment. Alternative 5 involves the placement of thin layers (approximately 6 inches or less) of new clean sediment or sand onto the marsh or waterway sediment surface. Pilot studies have indicated that thin layers of sediments may be feasibly placed and remain stable within the BCSA.

Thin-layer placement used for EMNR is not intended to provide a complete seal over impacted sediment, unlike a conventional isolation capping operation (ESTCP, 2009b), and is not designed to provide long-term isolation of contaminants from benthic organisms, except in combination with natural recovery processes (EPA, 2005). Instead, thin-layer placement provides a surface layer of clean material resulting in an immediate reduction in surface chemical concentrations, which facilitates the reestablishment of benthic organisms and minimizes short-term disruption of the benthic community (NRC, 2003; EPA, 2005). In relatively stable areas with limited episodic sediment resuspension and ongoing natural recovery, placement of thin layers of clean material facilitates and accelerates the natural recovery process and reduces bioavailability of constituents.

Treatability and pilot studies are ongoing to provide site-specific data related to this alternative. Data collected from these studies to date indicate the thin-layer placements remain physically stable and have reduced near-surface sediment COPC concentrations.

Thin-layer placement could be performed as a stand-alone remedy or could be combined with other alternatives such as removal to help mitigate potential residual COPCs. Risk reduction from the remedy would be monitored and adjustments, potentially including reapplication, would be made as necessary.

Alternative 5 includes ICs and MNR since this alternative requires monitoring to document continued recovery and long-term achievement of RAOs.

5.2.4.3 Alternative 6 – Thin-layer Placement with Amendment(s) + MNR + ICs

Alternative 6 is similar to Alternative 5 but includes the incorporation of amendments into or as layers of the thin-layer placement materials.

The use of amendments in thin-layer placement to reduce bioavailability of contaminants by sorption or by promoting contaminant degradation is identified by EPA as having the potential to improve resistance to high-energy flow events and advective transport of COPCs (EPA, 2013). Similar to thin-layer placement, amended thin-layer placement is not intended to provide a complete seal over impacted sediment or to provide long-term isolation of contaminants from benthic organisms, except in combination with natural recovery processes (EPA, 2005). Instead, thin-layer placement with amendments provides a surface layer of cleaner material that retards contaminant transport and reduces bioavailability by providing a new benthic layer. The placement also provides an immediate reduction in surface sediment COPC concentrations that facilitates the re-establishment of benthic organisms, minimizes short-term disruption of the benthic community, and further accelerates the process of physical isolation continued over time by natural sediment deposition (EPA, 2005, 2013).

Amendments evaluated as part of laboratory treatability studies and in ongoing field pilot studies include: (1) adsorption based amendments such as activated carbon and Organoclay-MRM, and (2) amendments that manipulate geochemical conditions to limit mercury methylation, such as zero-valent iron (ZVI).

Thin-layer placement with amendments could be performed as a stand-alone remedy in an ASM approach or could be combined with other alternatives such as removal or capping to help mitigate potential residual COPCs. Risk reduction from the remedy would be monitored and adjustments, including potentially reapplication, would be made as necessary.

Alternative 6 includes ICs and MNR since this alternative requires monitoring to document continued recovery and long-term achievement of RAOs.

5.2.5 Removal Alternatives (Alternatives 7 – 9)

Alternatives 7, 8 and 9 include sediment removal that would physically and permanently remove COPC mass in contaminated sediments from the environment. In marsh and waterway environments, removal is typically accomplished via dredges or specialty excavation equipment such as marsh buggies. The benefits and impacts from removal can both be significant and require thorough evaluation, especially in areas such as the BCSA waterways and marshes that are not already subject to routine anthropogenic sediment disturbances such as dredging to maintain navigational channels.

GSR analysis of removal actions can provide a more robust understanding of the trade-offs and community benefits in selecting removal as part of a remedy. Removal can also be sequenced in an adaptive context to optimize the amount of removal based on performance data and progress toward RAOs. This process can take into account that while removal technologies are typically efficient at removing bulk contaminant mass, they can also present significant challenges and limitations related to water management, habitat disturbance, resuspension and release of impacted sediment, as well as impacted sediment residuals that may remain after removal is complete.

The specific challenges related to removal are highly dependent on the specific removal technology selected. For example, sediment removal may be conducted in the dry if measures such as cofferdams or portadams are used. Removal in the dry typically presents fewer concerns related to resuspension and residuals than removal in the wet via a dredge, but removal in the dry requires greater consideration of water management such as managing tidal inundation, base flow management in waterways, and potential flooding due to storms or tides. Removal in the wet typically presents challenges related to resuspension and residuals that would need to be managed. Studies by the National Academies (NRC, 2007) and USACE (2008) have described challenges and limitations of dredging as a risk mitigation measure. Technologies and engineering measures are available to help mitigate these concerns and would be considered in the detailed evaluation of the alternatives.

Removal alternatives require fairly substantial logistical support and planning since removed sediment, as well as any backfill or cap material, would need to be managed and transported/conveyed between the work areas to the support/processing areas where the sediment would be transported off-site. Considering the shallow waterway depths and large surrounding marsh areas within the BCSA, the transport distances may be fairly large.

Partial or complete removal would destroy existing habitat within the marshes or waterways. Habitat restoration would need to be a component of the removal alternatives; however, based on the relatively sensitive environment in areas such as the BCSA marshes, it would require substantial short- and long-term efforts to successfully restore the impacted habitats and biological communities in the marshes (NYDEC, 2000).

5.2.5.1 Alternative 7 – Partial Contaminated Sediment Removal + Capping + MNR + ICs

Alternative 7 includes partial contaminated sediment removal and capping involves the removal of the upper layers of impacted sediment. An engineered cap of a sufficiently thick layer of clean sand or other appropriate material is placed over the remaining sediment to segregate the contaminated sediment from aquatic organisms that dwell or feed on, above, or within the cap. The engineered cap would be designed to provide a physical and chemical isolation barrier to limit potential erosion and disturbance of the sediment. The cap design would also include an appropriate layer to support establishment of a benthic community or restoration of habitat.

This alternative could be used in areas where an isolation cap is the recommended remedial approach, but removal is probably required to maintain habitat conditions within a marsh or to accommodate hydrodynamic conditions or prevent loss of water depth for habitat within a waterway. Management of resuspension and release of impacted sediments during removal and cap installation is important and potentially difficult to achieve in the waterways, particularly since more contaminated subsurface sediments are exposed during the removal process prior to capping.

Alternative 7 differs from the alternatives that use thin-layer placement. The engineered cap is designed to provide a completed remedy that does not rely on long-term natural recovery to achieve sediment RAOs. Once the cap is in place, sediment RAOs would be met. However, MNR and ICs are included in this alternative since achievement of some RAOs may require further natural recovery.

5.2.5.2 Alternative 8 – Full-Depth Contaminated Sediment Removal (without Backfill) + MNR + ICs

Alternative 8 is the removal of contaminated soft sediments to achieve RAOs with no further remedial activity. This may include removal of sediments to a depth where unacceptable risks are addressed sufficiently to achieve RAOs or a more general objective of down to the native Pleistocene clays underlying the BCSA in some areas. Alternative 8 does not include backfilling the excavation.

As with all removal-based alternatives, full-depth removal would effectively remove COPC mass from the BCSA, but would also require consideration of the potential negative impacts and logistical considerations related to excavating and transporting the sediment. Similar to other removal alternatives, Alternative 8 would destroy existing habitat. However, full depth removal without backfill would also preclude restoration to existing habitat conditions, except to the extent that the natural depositional process eventually results in restored habitat.

Removal without backfilling over large areas within the waterways would affect hydrodynamic patterns in the system, potentially creating unintended impacts in adjacent or nearby areas. The excavation also could act as sediment trap and therefore “starve” nearby areas of clean sediment entering the system, inhibiting the natural recovery of those areas. Full depth removal without backfill would also potentially impact the stability of the system (e.g., loss of mudflats, high bank erosion rates in marshes).

MNR and ICs are included in this alternative since achievement of some RAOs may require further natural recovery.

5.2.5.3 Alternative 9 – Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs

Alternative 9 includes the same removal concept as Alternative 8 but includes backfilling the sediment removal areas. This may include complete backfilling to approximate the original grades or in waterways partial backfilling of the excavated areas.

As with all removal based alternatives, full-depth removal with backfilling would effectively remove COPC mass from the BCSA, but would also require consideration of the potential negative impacts and logistical considerations related to excavating and transporting the sediment. Backfilling incorporated into this alternative could help to mitigate potential effects of resuspension or redistribution of COPCs.

Similar to other removal alternatives, Alternative 9 would destroy existing habitat. However, backfilling could be used to support full or partial restoration of the habitat although reestablishing habitat, especially tidal marsh, can be challenging and require extended periods of operation and maintenance.

Backfilling excavated areas within the waterways would also reduce potential negative impacts to hydrodynamic patterns in the system or to the stability of the surrounding areas.

MNR and ICs are included in this alternative since achievement of some RAOs may require further natural recovery.

5.2.6 Alternative 10 – Hydraulic/Hydrologic Controls + MNR + ICs

Alternative 10 is a marsh-only alternative and not evaluated under waterway alternatives although the technologies (e.g. tide control structures, etc.) included in this alternative may be considered as a component of a waterways alternative as appropriate during the detailed alternatives analysis. Implementation of hydraulic/hydrologic controls involves modifications to existing hydrodynamic conditions via structures such as weirs or tide gates or modifications of drainage features such as ditches. This alternative includes a fairly wide range of potential technologies or engineering designs that could be targeted to specific objectives based on specific subareas that may be identified in the detailed alternatives analysis.

For example, controls such as active weirs could be used to encourage deposition of cleaner sediment in the marsh tributaries or targeted marsh areas. The deposited sediments would enhance natural recovery within the targeted areas (ESTCP, 2009b). An active weir could be designed to temporarily retain water during periods such as ebb tides to help encourage sedimentation. As appropriate, these structures could also be designed to open prior to potential flood events to avoid negative impacts of flooding. Other technologies may have applicability depending on location specific conditions and objectives. Examples include: reconfiguration of marsh tributary channels to encourage sediment deposition; rerouting marsh tributary drainage channels from highly impacted areas to unimpacted areas to reduce the potential for future exchange of impacted material between waterways/tributaries to the marshes; or technologies such as active tidegates to manage energy within the system. The selection and design of specific structures or controls would need to be developed on a location specific basis and would need to carefully consider and manage potential negative impacts such as flood/storm conditions, marsh ecology/hydrologic/sediment balance needs to maintain marsh and waterway stability, and marsh and waterway geochemistry (e.g. oxygen content and salinity). These technologies may also be able to provide benefits related to flood hazard mitigation and potential impacts related to sea-level rise depending on the specific technology and design selected.

For (future) detailed evaluation as part of the FS, this alternative would potentially be considered as a stand-alone alternative for specific targeted areas or used with other alternatives as part of a combined remedy.

Hydraulic and hydrodynamic controls could be a component of an ASM approach to the remedial action implementation. Risk reduction would be monitored and adjustments could be made as necessary. MNR and ICs are included in this alternative since achievement of some RAOs will require further natural recovery.

5.3 Management of Materials for Disposal

Management of removed materials is a component of any removal alternative. The general concept for dredged material transportation and management is described below.

Sediment removed as part of a remedial action would be classified for waste disposal and disposed in an environmentally appropriate manner. As the sediment removal and disposal volumes are not known at this time, specific consideration of disposal options is deferred until the detailed alternatives analysis. The detailed alternatives analysis will consider a full range of options including off-site disposal and potential on-site options within the context of land use plans and restrictions in the BCSA.

For contaminated sediment removal alternatives, several factors will be evaluated related to management of the sediments. Particular considerations include the limited availability for upland sediment processing areas due to significant upland development. This will pose logistical challenges for the establishment of support areas and facilities for the management of sediments. Sediment removed from the BCSA would require dewatering and possibly stabilization to manage free liquids prior to disposal. The sediment handling and dewatering operation would require fairly large amounts of space and need to be located in an area with reasonable access to the BCSA waterways and marshes and to roadways for transportation of the sediment. Depending on the removal location, separate facilities may also be required for each major work area to provide for efficient transfer of materials from the work area to the processing area. Transportation of the sediment for disposal would require detailed evaluation of logistical and public safety considerations. These factors would be considered as part of the future detailed alternatives analysis.

SECTION 6

REMEDIAL ALTERNATIVES SCREENING

6.1 Screening Process Overview

The remedial alternatives described in Section 5 were evaluated based on their relative effectiveness, implementability, and cost in accordance with EPA's RI/FS Guidance (EPA, 1988). Since the RI and risk assessment are ongoing, specific SMUs cannot be identified at this time. Therefore, the alternatives were evaluated in view of sets of Site characteristics. The Site characteristics considered for evaluating effectiveness were area risk, stability, and natural recovery status. The characteristics considered for evaluating implementability were area accessibility, technical implementability, and administrative feasibility of the alternative. While there is a range of these general characteristics within the BCSA, for the purpose of this evaluation each characteristic was broken down into two general categories (e.g., higher/lower risk). How specific locations within the BCSA match up with these characteristics remains to be determined through the continued RI and risk assessment processes. In later stages of the FS process, area-specific conditions will be evaluated relative to the expected effectiveness (both short and long term) and implementability of potential alternatives that will be developed for specific subareas of the site.

The screening process was not designed to be an alternatives ranking process. Ranking will be performed as part of the detailed alternatives evaluation to be conducted after the risk assessment is completed. The remedial alternatives were rated for each of the effectiveness and implementability criteria to identify major issues that could affect the viability of a particular alternative. The cost criterion was also rated. Again, the ratings are not intended to lead to developing a total alternative score.

6.2 Conditions Matrix: Effectiveness, Implementability, and Cost

The evaluation process is based on the projected performance of each alternative relative to key site characteristics that reflect the range of conditions within the BCSA. These area characteristics are evaluated in a matrix approach as presented in Tables 6-1 through 6-3 for waterways and Tables 6-4 through 6-6 for marshes. For each evaluation condition, a higher and lower value was considered for the purposes of the DSRAM. For example, the screening considers how each alternative would perform for an area with lower risk, higher stability, and higher natural recovery rate. In this way, the DSRAM evaluation will support the future detailed evaluation of alternatives for specific SMUs within the BCSA.

The evaluation of effectiveness is summarized in Tables 6-1 and 6-4 for waterways and marshes, respectively. Remedial alternatives were listed under the Alternative column and the effectiveness of each alternative was rated for three area characteristics: risk, stability, and natural recovery rate. The tables use a symbolic rating system plus comments to concisely present the basis and considerations for each rating. The symbolic rating system uses the following scale:

✓✓	Highly effective
✓	Effective
0	Possibly Effective
X	Likely Not Effective
XX	Not Effective
NA	Not Applicable

The evaluation for implementability uses a similar scale in Tables 6-2 and 6-5 for waterways and marshes, respectively:

✓✓	Highly Implementable
✓	Implementable
0	Possibly Implementable
X	Likely Not Implementable
XX	Not Implementable
NA	Not Applicable

The focus of cost evaluation at this development and screening of alternatives stage of the FS process is comparative estimates (EPA, 1988). Detailed cost estimates were not used in the screening process. Remedial alternatives were not developed for specific areas within the BCSA so volumes or areas of (impacted) media were not identified. The cost evaluation was instead based on professional judgment and experience as to whether each remedial alternative has a low, mid-range, or high cost to implement relative to other alternatives. The (future) detailed evaluation of alternatives will include development of budget-level cost estimates in accordance with the recommendations of EPA's RI/FS Guidance. The symbolic rating system for cost in Tables 6-3 and 6-6 is:

✓✓	Very Low Cost
✓	Low Cost

0	Mid-range Cost
X	High Cost
XX	Very High Cost
NA	Not Applicable

The alternatives analysis effort screened out (eliminated) only one alternative, Alternative 8 – Full-Depth Removal without Backfill, for both waterways and marshes. However, the relatively low ratings of some alternatives indicate that their potential applicability is limited for certain site conditions. For example, MNR+IC rates low for effectiveness for a relatively high risk, low stability, and low natural recovery area. Removal alternatives, on the other hand, rate low for effectiveness and implementability in areas with relatively low risk, high stability, high natural recovery, and limited accessibility.

6.3 Effectiveness Evaluation Criteria

The effectiveness of alternatives is evaluated relative to risk, stability, and natural recovery conditions. Both short-term and long-term effectiveness are considered in the evaluation.

6.3.1 Area Risk

Area risk refers to the relative human health or ecological risk posed by an area based on risk assessment evaluations and is generally representative of the relative COPC concentration range in the surface sediments and the potential for receptors to be exposed to these COPCs. The range of actual risks present in the BCSA remain to be determined as well as the specific conditions that represent higher or lower risk. In addition, risk within a given area may change over time due to natural recovery, disturbance or the influence of remedial actions conducted in other areas of the system that encourage natural recovery.

For the current evaluation, “higher risk” refers to areas with COPC concentrations or conditions that can pose adverse acute or chronic effects to human health or the ecological community. “Lower risk” refers to areas with COPC concentrations or conditions that may pose a risk on the relatively low end of the actionable range.

6.3.2 Area Stability

Area stability refers to whether the physical, geochemical, and biological conditions within an area are likely to remain stable over time. Conditions such as physical makeup of sediment, observed physical stability of sediment, geochronology, and hydrologic conditions would be considered to evaluate the stability of an area. Other conditions such as vegetative surface cover and physical features would be considered in the stability evaluation for specific SMUs.

For the current evaluation, "lower stability" refers to areas with physical, geochemical, and biological conditions that are anticipated to be subject to possible changes due to hydrodynamic energy and anthropogenic impacts. By contrast, the term "higher stability" refers to areas in which no significant changes in physical, geochemical, and biological conditions are anticipated in the long term.

The RI studies have shown marshes to be very stable; therefore, consideration of lower stability areas is not applicable to marsh alternatives, as indicated on Table 6-4.

6.3.3 Natural Recovery Status

Natural recovery refers to decreasing near-surface COPC concentrations over time. A detailed natural recovery analysis considers multiple lines of evidence, but one important consideration is whether there is deposition of clean sediment as indicated by progressively lower bulk COPC concentrations over time in shallow sediments as compared to deeper sediment layers (in areas where there are elevated deeper COPC concentrations). Similarly, in areas with low concentrations in deeper sediment, shallow sediment concentrations that remain consistently low indicate ongoing natural recovery. Areas that are recovering naturally would have reduced risk over time without remedial intervention.

For the current evaluation, "lower natural recovery" refers to areas with no or limited decrease in COPC concentrations in the surface sediment as compared to subsurface deeper sediment. "Higher natural recovery" refers to areas with multiple lines of evidence to support decreasing COPC concentrations in shallow surface sediment as compared to subsurface deeper sediment.

6.4 Implementability Evaluation Criteria

Implementability of alternatives is evaluated relative to area accessibility and considerations related to habitat disturbance and restoration. Alternatives are also evaluated in the context of the inherent characteristics of each alternative that are not dependent on specific Site conditions. These characteristics of the alternatives include technical implementability and administrative feasibility.

6.4.1 Area Accessibility

Area accessibility refers to the degree to which construction equipment, materials, and crews can readily access or be transported to areas for remedy implementation. The accessibility evaluation considers the type of equipment and amount of material that would likely be removed from or brought into the area for each alternative. For waterways, conditions such as size and width of surrounding marsh, distance from potential support areas, channel water depths, and channel width factor into the accessibility evaluation. For marshes, factors such as size and width of the marsh, proximity to roads, geotechnical stability of the surrounding area, and potential upland staging areas were considered.

For the current evaluation, "less accessible" refers to areas where access for transportation of construction equipment, material, and crews is limited due to physical barriers (natural and man-made), lack of navigable water depth, or narrow channel width for water-based access, and/or longer distances to the remedial area from upland points of access.

6.4.2 Alternative Characteristics

The alternative characteristics evaluation addresses technical implementability and administrative feasibility.

Technical implementability refers to whether: 1) the equipment and technology are readily available commercially for large-scale implementation; 2) site-specific bench- and/or pilot-scale testing has been performed to demonstrate implementability; and 3) site-specific conditions have been identified that could challenge large-scale implementation.

Administrative feasibility refers to: 1) the availability of remedial resources (e.g., clean capping material, amendments, landfill capacity) in case of large-scale application of an alternative, and 2) ability to obtain regulatory approval for an alternative due to site-specific concerns (e.g., net loss of wetlands, flood hazard mitigation).

6.5 Evaluation Screening Results

The screening evaluation for waterways is presented in Tables 6-1 to 6-3 and for marshes in Tables 6-4 to 6-6. The rating evaluation results for effectiveness, implementability, and cost are presented for each waterway and marsh remedial alternative in summary tables in the following subsections. For each remedial alternative, the evaluation narrative provides site-specific context, key benefits and limitations, and a statement as to whether the alternative will be retained for the detailed alternatives evaluation process.

6.6 Evaluation of Waterway Remedial Alternatives

6.6.1 Alternative 1 – No Action

Evaluation

Alternative 1 – No Action will be retained in the detailed alternatives evaluation as it is required to be evaluated by the NCP.

6.6.2 Alternative 2 – Institutional Controls (ICs) (alone)

Effectiveness	Area Risk	Lower Risk	0 – Possibly effective
		Higher Risk	XX – Not effective
	Area Stability	Lower Stability	XX – Not effective
		Higher Stability	0 – Possibly effective
	Natural Recovery	Lower NR	XX – Not effective
		Higher NR	0 – Possibly effective
Implementability	Area Accessibility	Less Accessible	✓✓ – Highly implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		✓✓ – Very low cost

Evaluation

Alternative 2 – ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

ICs can contribute to remedy effectiveness at low cost in low risk and highly stable areas that do not require monitoring; however, ICs are not effective as a stand-alone alternative since they cannot achieve RAOs and are not effective for protection of ecological receptors. The expectation is that ICs alone are applicable only in areas of very low risk or in conjunction with other alternatives.

The cost for this alternative alone is very low.

6.6.3 Alternative 3 – MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓ – Effective
		Higher Risk	XX – Not effective
	Area Stability	Lower Stability	XX – Not effective
		Higher Stability	✓ – Effective
	Natural Recovery	Lower NR	0 – Possibly effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓✓ – Highly implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		✓ – Low cost

Evaluation

Alternative 3 – MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

The RI studies have shown that the BCSA waterways are overall net depositional with localized episodic depositional and/or erosional areas (e.g., tributary confluences, NJSEA stormwater outlet, deep waterway channels). Although MNR + ICs would be effective in higher stability and higher natural recovery areas, MNR + ICs alone would not be effective and feasible in lower stability areas. For the lower natural recovery areas, a question remains as to the time period for achieving RAOs; therefore, MNR is rated possibly effective in these areas. For areas with higher risks, MNR would not generally be effective, unless the area is undergoing rapid natural recovery. MNR is also susceptible to anthropogenic actions; for this reason, the effectiveness of MNR would be dependent on the implementation and effectiveness of the accompanying ICs.

MNR is assessed to be highly implementable in all areas as physical access for periodic monitoring is not an issue for the alternative. MNR does not include active remedial measures that would require consideration of permit equivalencies and similar approaches have been approved and implemented at applicable portions of other sites; therefore, MNR rates as highly implementable in relation to regulatory approvals.

MNR would also likely be a component of other remedial alternatives in higher risk and lower stability areas.

The cost to implement MNR + ICs over a portion of the waterways is low relative to other alternatives.

6.6.4 Alternative 4 – Direct Application of Treatment Amendment + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓ – Effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	XX – Not effective
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	0 – Possibly effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		0 – Mid-range cost

<u>Evaluation</u>

Alternative 4 – Direct Application of Treatment Amendment + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

Treatability study work completed to date has shown that amendments such as activated carbon are effective in sorbing the target COPCs. MNR alone may not be effective in areas of higher risk or lower rates of natural recovery, since it may not achieve RAOs in an acceptable time frame. Direct application of treatment amendment can enhance the natural recovery process and lower the time needed to achieve RAOs. Alternative 4 is assessed to be highly effective in areas of lower risk, higher stability and higher natural recovery since these areas are already stable and recovering and the amendments would help to reduce the short- and long-term risks. For example sorption of COPC by the amendment could limit bioavailability of COPCs in the short term by binding these constituents. These same benefits could also apply in the long-term. Since these factors also apply to areas with lower rates of natural recovery, Alternative 4 can also possibly be effective in lower natural recovery areas. This alternative can be applied in an ASM approach, including potential application of additional amendments subsequent to the initial application.

This alternative is rated ineffective for areas with low stability. Direct application of amendments is not intended as an isolation technology. It is anticipated that the amendments would naturally mix with the surface sediments over time. However, for the amendments to be effective they need to generally remain in place.

Direct application of treatment amendment is implementable under most conditions. The alternative generally involves transport and placement of less material than other active alternatives. Therefore the size and type of equipment needed to implement this alternative is less affected by space and draft limitations as compared to other alternatives. Direct application of amendments is assessed to be highly implementable with currently available technology and for anticipated monitoring requirements.

Amendment addition is not anticipated to present regulatory approval challenges from a permit equivalency standpoint. Since it involves placement of relatively low masses/thicknesses of material, this alternative would not likely raise concerns related to changes in channel depth.

Direct application of treatment amendment may also be a component of other remedial alternatives.

The cost of amendment addition over a portion of the waterways is moderate compared to other alternatives.

6.6.5 Alternative 5 – Thin-Layer Placement + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓✓ – Highly effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	XX – Not effective
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	0 – Potentially effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		0 – Mid-range cost

<u>Evaluation</u>

Alternative 5 – Thin-Layer Placement will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

In localized erosional, lower stability areas of the BCSA, thin-layer placement may not be feasible. Thin-layer placement is considered to be highly effective in higher stability and higher natural recovery areas, and in low risk areas. For high-risk areas, thin-layer placement is considered possibly effective. While this alternative is expected to reduce surface COPC concentrations, intermixing of the thin layer material with underlying sediment in areas with higher initial COPC concentrations may extend time frames to achieve RAOs compared to areas with lower concentrations. The alternative can be applied in an ASM approach with additional thin-layer placement conducted subsequent to the initial placement based on review of the performance monitoring data in achieving remedial objectives.

Thin-layer placement is susceptible to anthropogenic actions such as construction in the waterway, so effectiveness would be supplemented by implementation and enforcement of ICs. Thin-layer placement should not have significant short- or long-term detrimental impact on waterway habitat.

Thin-layer placement is implementable under most conditions. The alternative involves transport and placement of less material than other active alternatives except possibly Alternative 4.

Therefore the size and type of equipment needed to implement this alternative is less affected by space and draft limitations as compared to alternatives such as removal. Pilot studies have demonstrated the implementability and physical stability of thin-layer placement plots on mudflats in the waterways. The layer can be placed with currently available technology. Thin-layer placement is assessed to be highly implementable from the standpoint of the availability of remedial resources.

Thin-layer placement was rated highly implementable from a regulatory permit equivalency standpoint. The thin layers of sediment placed are not predicted to significantly affect channel depths or waterway geometry in a manner that would prevent regulatory permit consistency or other approvals related to the work. Pilot study monitoring of thin-layer placement indicates that the sediment returns to the pre-addition elevation as a result of consolidation and compaction of underlying sediment.

This alternative may also be a component of other remedial alternatives.

The cost of thin-layer placement + MNR + ICs over a portion of the waterways is moderate compared to other alternatives.

6.6.6 Alternative 6 – Thin-Layer Placement with Amendment + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓✓ – Highly effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	XX – Not effective
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		0 – Mid-range cost

<u>Evaluation</u>

Alternative 6 – Thin-Layer Placement with Amendment + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

The benefits and limitations described under Alternative 5 also apply to Alternative 6. Additionally, treatability studies completed to date have shown that amendments are effective in sorbing the target COPCs. This alternative is potentially somewhat more effective than thin-layer placement alone (Alternative 5) in areas with lower natural recovery since the amendments can help to absorb COPCs that may be present during the slower natural recovery process.

This alternative may also be a component of other remedial alternatives.

The cost of Alternative 6 is assessed to be moderate but slightly more costly than Alternative 5.

6.6.7 Alternative 7 – Partial Contaminated Sediment Removal + Capping+ MNR + ICs

Effectiveness	Area Risk	Lower Risk	0 – Possibly effective
		Higher Risk	✓ – Effective
	Area Stability	Lower Stability	✓ – Effective
		Higher Stability	0 – Possibly effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	✓ – Effective
Implementability	Area Accessibility	Less Accessible	0 – Possibly Implementable
		Readily Accessible	✓ – Implementable
	Alternative Characteristics	Technical Implementability	✓ – Implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		XX – Very high cost

<u>Evaluation</u>

Alternative 7 – Partial Contaminated Sediment Removal + Capping + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

An isolation cap could be up to 1 to 2 feet thick and, where applicable, could include additional backfill material to establish target grades/surface profiles. Installation of an isolation cap would require partial removal of soft sediment prior to capping in order to maintain area hydrodynamics and minimize altering the existing type of habitat (e.g., limit transformation of the subtidal areas into mudflats and mudflats into marsh or uplands). Partial removal of soft sediment would effectively and permanently remove COPC mass from the BCSA. Partial sediment removal would also increase short-term risks due to resuspension of the bed sediment and the concomitant release of contaminants from bedded sediments, and habitat destruction. These negative impacts can potentially be reduced/mitigated through careful selection and design of removal techniques. For example, removal in the dry can have less potential for resuspension, redistribution and residuals, but also requires substantial water management. The cap materials would also help to manage residuals and mitigate the short-term risks. This alternative is considered effective in higher risk areas, because the long-term benefits can offset short-term risks. Partial removal with capping is evaluated to be only possibly effective in lower risk areas, however, because the removal activities may not provide sufficient long-term benefits compared to the short-term risks.

Design of the cap and restoration of waterway channels and mudflat areas can be challenging and requires careful consideration of hydrodynamics and bed geomorphology to avoid destabilizing portions of the waterways or adjacent marshes. Therefore, this alternative is only considered possibly effective in higher stability areas, due to the potential net adverse impact of the alternative on those areas.

Removal alternatives require more transportation of equipment and materials than other alternatives, so these alternatives are rated Possibly Implementable for areas with limited access. (e.g., narrow and shallow waterway locations and marsh tributaries and waterway areas far from roadways). Transportation of equipment into and out of readily accessible areas poses challenges but is assessed to be implementable.

Partial removal and capping is not anticipated to present regulatory approval or permit equivalency challenges.

The cost of installation of this alternative is relatively very high due to the cost of material removal, transportation and disposal, and procurement and placement of cap material.

6.6.8 Alternative 8 – Full-Depth Contaminated Sediment Removal (without Backfill) + MNR + ICs

Effectiveness	Area Risk	Lower Risk	0 – Possibly effective
		Higher Risk	✓ – Effective
	Area Stability	Lower Stability	XX – Not effective
		Higher Stability	XX – Not effective
	Natural Recovery	Lower NR	XX – Not effective
		Higher NR	X – Likely not effective
Implementability	Area Accessibility	Less Accessible	0 – Possibly Implementable
		Readily Accessible	✓ – Implementable
	Alternative Characteristics	Technical Implementability	X – Likely not Implementable
		Availability of Remedial Resources	✓ – Implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		XX – Very high cost

<u>Evaluation</u>

Alternative 8 – Full-Depth Contaminated Sediment Removal without Backfill + MNR + ICs will not be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

Removal of soft sediment would effectively and permanently remove COPC mass from the BCSA. Overall, this alternative has the same potential short-term risks as Alternative 7; however, there is no backfill or cap to help mitigate the short-term impacts. In addition, removal without backfill would result in significant hydrodynamic changes to the work area and areas up and downstream. These changes may destabilize channels and marshes in a natural system as new flow and sediment transport patterns become established. If performed on small scale or targeted areas, these issues may be less of a consideration. Based on these considerations, removal without backfill is not considered to be effective under most conditions expected within the BCSA. There may be small or targeted areas, where this alternative may be effective as a component of a larger combined alternative.

Removal alternatives require more transportation of equipment and materials than other alternatives, so these alternatives are rated Possibly Implementable for areas with limited access. (e.g., narrow and shallow waterway locations and marsh tributaries and waterway areas far from roadways). Transportation of equipment into and out of readily accessible areas poses challenges but is assessed to be implementable.

Disposal of a large volume of material generated as a result of the removal could be limited by daily landfill capacity, and for this reason this alternative is rated implementable for availability of remedial resources. Full depth contaminated sediment removal without backfill is not anticipated to present any particular regulatory approval challenges such as permit equivalencies.

The anticipated cost is very high due to the cost of material removal, transportation, and disposal.

6.6.9 Alternative 9 – Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs

Effectiveness	Area Risk	Lower Risk	0 – Possibly effective
		Higher Risk	✓ – Effective
	Area Stability	Lower Stability	✓ – Effective
		Higher Stability	0 – Possibly effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	✓ – Effective
Implementability	Area Accessibility	Less Accessible	0 – Possibly Implementable
		Readily Accessible	✓ – Implementable
	Alternative Characteristics	Technical Implementability	✓ – Implementable
		Availability of Remedial Resources	✓ – Implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		XX – Very high cost

<u>Evaluation</u>

Alternative 9 – Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

The benefits and limitations described under Alternative 7 also apply to Alternative 9. Alternative 9 would effectively and permanently remove a larger mass of COPCs than other alternatives with the exception of Alternative 8. However, this alternative requires removal to greater depths and volumes and correspondingly longer implementation timeframes. These factors potentially increase the short-term risks compared to Alternative 7. Backfilling would potentially mitigate some of the short-term risks. In areas such as higher risk or lower stability areas, the long-term benefits may outweigh the short-term risks. In lower risk, higher stability areas, the short-term risks may outweigh the long-term benefits and reduce the relative effectiveness of this alternative.

Restoration of waterway channels and mudflat areas can be challenging and requires careful consideration of hydrodynamics and bed geomorphology to avoid destabilizing portions of the waterways or adjacent marshes. The placement of sediment with a grain size distribution different from the native material (e.g. replacement of organic mud with sand) would initially result in different habitat characteristics as well as redistribution of new sediment in the new channel as a new dynamic equilibrium is established over the range of flow conditions. Therefore, this alternative is considered possibly effective in higher stability areas, due to the potential net adverse impact of the alternative on those areas.

Removal alternatives require more transportation of equipment and materials than other alternatives, so these alternatives are rated Possibly Implementable for areas with limited access (e.g., narrow and shallow waterway locations and marsh tributaries and waterway areas far from roadways). Transportation of equipment into and out of readily accessible areas poses challenges but is assessed to be implementable.

Sediment removal with backfill is not anticipated to present regulatory approval or permit consistency challenges.

The cost of full-depth removal and backfill over a significant portion of the waterways is very high.

6.7 Evaluation of Marsh Remedial Alternatives

6.7.1 Alternative 1 – No Action

Evaluation

Alternative 1 – No Action will be retained in the detailed alternatives evaluation as it is required to be evaluated by the NCP.

6.7.2 Alternative 2 – Institutional Controls (ICs) (alone)

Effectiveness	Area Risk	Lower Risk	0 – Possibly effective
		Higher Risk	XX – Not effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	0 – Possibly effective
	Natural Recovery	Lower NR	XX – Not effective
		Higher NR	0 – Possibly effective
Implementability	Area Accessibility	Less Accessible	✓✓ – Highly implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		✓✓ – Very low cost

Evaluation

Alternative 2 –ICs will be retained as an alternative for consideration in the detailed alternatives evaluation.

ICs alone can contribute to remedy effectiveness at low cost in low risk and highly stable areas that do not require monitoring; however, ICs may not be effective as a stand-alone alternative since they cannot achieve RAOs and are not effective for protection of ecological receptors, which are the primary receptors of concern in the marshes.

ICs would potentially be a component of the selected alternative for marshes.

The cost of ICs is evaluated to be very low.

6.7.3 Alternative 3 – Monitored Natural Recovery + ICs

Effectiveness	Area Risk	Lower Risk	✓✓ – Highly effective
		Higher Risk	XX – Not effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	0 – Possibly effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓✓ – Highly implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		✓ – Low cost

Evaluation

Alternative 3 – Monitored Natural Recovery + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

RI studies have shown that the BCSA marshes in the tidal area are consistently net depositional. The marshes contain dense vegetation which promotes relatively low water velocities and traps sediments. Thus, marshes are not susceptible to erosion, even during storm events as the *Phragmites* marshes absorb the energy of storm surges and reduce the potential for and degree of flooding. MNR + ICs are assessed to be highly effective in lower risk and higher stability areas. For areas with higher risks, MNR would not generally be effective, unless the area is undergoing rapid natural recovery.

MNR + ICs are highly implementable, as access to even less accessible areas would not be an issue. MNR is not anticipated to pose any administrative challenges or concerns related to permit equivalencies. Similar approaches have been approved and implemented at other sites.

MNR + ICs would likely be a component of other remedial alternatives.

The cost of MNR + ICs over a portion of the marshes is low.

6.7.4 Alternative 4 – Direct Application of Treatment Amendment + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓✓ – Highly effective
		Higher Risk	X – Likely not effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓✓ – Highly implementable
Cost	Relative Cost		**0** – Mid-range cost

Evaluation

Alternative 4 – Direct Application of Treatment Amendment + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

Treatability study work completed to date has shown that amendments such as activated carbon are effective in sorbing the target COPCs. MNR alone may not be effective in areas of higher risk or lower rates of natural recovery, since it may not achieve RAOs in an acceptable time frame. Direct application of treatment amendment can enhance the natural recovery process and lower the time needed to achieve RAOs. Alternative 4 is assessed to be highly effective in areas of lower risk, higher stability and higher natural recovery since these areas are already stable and recovering and the amendments would help to reduce the short- and long-term risks. For example sorption of COPC by the amendment could limit bioavailability of COPCs in the short term by binding these constituents. These same benefits could also apply in the long-term. Since these factors also apply to areas with lower rates of natural recovery, Alternative 4 can also possibly be effective in lower natural recovery areas. This alternative can be applied in an ASM approach, including potential application of additional amendments subsequent to the initial application.

Direct application of treatment amendments is implementable under most conditions. The alternative involves transport and placement of less material than other active alternatives. Therefore, the size and type of equipment needed to implement this alternative is less affected by space and access limitations as compared to other alternatives. Direct application of amendments is assessed to be highly implementable with currently available technology and for anticipated monitoring requirements.

Amendment addition is not anticipated to present regulatory approval challenges from a permit equivalency standpoint. There would be some regulatory consideration related to the placement of materials in wetlands, but because amendment addition involves placement of relatively low masses/thicknesses of materials, substantial regulatory challenges are not anticipated.

This alternative may also be a component of other remedial alternatives.

The cost of direct application of amendments + MNR + ICs over a portion of the marshes is moderate compared to other alternatives.

6.7.5 Alternative 5 – Thin-Layer Placement + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓✓ – Highly effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓ – Implementable
Cost	Relative Cost		0 – Mid-range cost

<u>Evaluation</u>

Alternative 5 – Thin-Layer Placement + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

The thin-layer placement alternative is considered to be highly effective in areas with lower risks, higher stability, and higher natural recovery. Placement of a thin layer of clean material would result in lower COPC concentrations in the surface sediment intervals and BAZ, particularly in areas where the sediment is stable and generally cleaner sediment continues to deposit on the surface and facilitate natural recovery. The placement of a thin layer of clean sediment as an additional barrier would facilitate recovery even in lower natural recovery areas and, for this reason; thin-layer placement is assessed to be effective in those areas as well.

For higher risk areas thin-layer placement is considered possibly effective. While the alternative is expected to reduce surface COPC concentrations, intermixing of the thin layer material with underlying sediment (e.g. through mechanisms such as plant growth through the material) may extend time frames to achieve RAOs in areas with higher initial COPC concentrations. The alternative can be applied in an ASM approach with additional thin-layer placement conducted after the initial placement based on review of progress in achieving remedial objectives.

Thin-layer placement is not expected to have significant short- or long-term detrimental impacts on marsh stability. However, as with any alternative requiring construction in the marsh, care would be needed during construction to reduce short-term impacts and disturbance to the marsh.

Thin-layer placement is generally implementable under most conditions. The alternative involves transport and placement of less material than other active alternatives except Alternative 4. Therefore, the size and type of equipment needed to implement this alternative is less affected by access limitations as compared to alternatives such as removal. Pilot studies have demonstrated the implementability and physical stability of thin-layer placement plots on mudflats in the waterways. Thin-layer placement is assessed to be highly implementable from the standpoint of the availability of remedial resources.

Thin-layer placement in the wetlands would require consideration of permit equivalencies related to NJDEP and USACE wetlands requirements, including those related to impact avoidance, minimization, and compensatory mitigation. Thin-layer placement could be considered filling within wetlands, which could present a regulatory approval challenge. However, similar remedial actions have been approved at other sites and thin-layer placement in marshes may not result in a net elevation change in the marsh surface over the long-term considering settlement and consolidation/degradation of organic materials. Depending on the design, this alternative may also provide net benefits (e.g. off-set sea-level rise, potential habitat improvements through diversity of wetland types, etc.).

This alternative may also be a component of other remedial alternatives.

The cost of thin-layer placement + MNR + ICs over a portion of the marshes is moderate compared to other alternatives.

6.7.6 Alternative 6 – Thin-Layer Placement with Amendments + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓✓ – Highly effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	✓✓ – Highly effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	✓✓ – Highly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	✓✓ – Highly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓ – Implementable
Cost	Relative Cost		0 – Mid-range cost

<u>Evaluation</u>

Alternative 6 – Thin-Layer Placement with Amendment + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

The effectiveness and implementability considerations described under Alternative 5 also apply to Alternative 6. Alternative 6 is generally considered to be effective and implementable in all areas. Effectiveness is less certain for areas with higher risks, as described in Alternative 5. Alternative 6 may provide somewhat greater short- and long-term effectiveness than Alternative 5 since Alternative 6 includes amendments that would potentially bind COPCs.

This alternative may also be a component of other remedial alternatives.

The cost of Alternative 6 is assessed to be moderate but slightly more costly than Alternative 5.

6.7.7 Alternative 7 – Partial Contaminated Sediment Removal + Capping + MNR + ICs

Effectiveness	Area Risk	Lower Risk	X – Likely not effective
		Higher Risk	✓ – Effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	X – Likely not effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	0 – Possibly effective
Implementability	Area Accessibility	Less Accessible	0 – Possibly implementable
		Readily Accessible	✓ – Implementable
	Alternative Characteristics	Technical Implementability	X - Likely not implementable
		Availability of Remedial Resources	0 – Possibly implementable
		Ability to Obtain Regulatory Approvals	0 – Possibly implementable
Cost	Relative Cost		XX – Very high cost

<u>Evaluation</u>

Alternative 7 – Partial Contaminated Sediment Removal + Capping + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

Installation of an isolation cap requires removal of sediment prior to capping in order to maintain existing system hydrodynamics and avoid altering the existing type of habitat (e.g., avoid changing marsh areas into uplands). Partial removal of soft sediment would effectively and permanently remove COPC mass from the BCSA. Removal in the marshes would include removal of the root mat of the *Phragmites*, which would destabilize the marshes in the short term and potentially limit the effectiveness of the alternative by re-exposing buried COPCs. The cap materials would help to manage residuals and mitigate the short-term risks.

This alternative is considered effective in higher risk areas because the long-term benefits may offset short-term risks. Partial removal with capping is evaluated to be only possibly effective in lower risk areas, however, because the removal activities may not provide sufficient long-term benefits compared to the short-term risks.

The net effectiveness of this and the other removal alternative may be offset by potential disruptions to the BCSA marshes. The dense root structure of the *Phragmites* is the fundamental source of stability within BCSA marshes. Large-scale sediment removal in the marshes would require removal of the protective vegetative cover and expose the underlying sediments.

Backfilling and restoration of the marshes would pose a substantial implementation challenge. There is a large measure of uncertainty regarding the ability to recreate a stable marsh environment after removal of the marsh surface over a large area. Design of the cap and restoration of marshes in a tidal estuary can be challenging and must factor in critical marsh surface elevations in relation to tidal inundation, sea-level rise, regulatory fill restrictions, geotechnical considerations, and biological requirements. For this reason, although the removal and capping technologies are well-established and equipment is available, the alternative is evaluated likely not technically implementable. In addition, if the restoration is unsuccessful, the long-term benefits may be outweighed by the short-term risk from an effectiveness perspective.

Removal alternatives require more transportation of equipment and materials than other alternatives, so these alternatives are rated Possibly Implementable for areas with limited access. Transportation of equipment into and out of readily accessible areas poses challenges but is assessed to be implementable.

Partial contaminated sediment removal and capping of the marshes would require consideration of NJDEP and USACE wetlands requirements, including those related to impact avoidance, minimization, and compensatory mitigation. Destruction of habitat is the least-favored alternative under USACE wetlands permitting policy (EPA, 1990). Removal alternatives in general have a higher likelihood of habitat damage and destruction as compared to non-removal alternatives

The cost of partial removal + installation of an isolation cap over a significant portion of the marshes is very high.

6.7.8 Alternative 8 – Full-Depth Contaminated Sediment Removal (without Backfill) + MNR + ICs

Effectiveness	Area Risk	Lower Risk	X – Likely not effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	X – Likely not effective
	Natural Recovery	Lower NR	0 – Possibly effective
		Higher NR	0 – Possibly effective
Implementability	Area Accessibility	Less Accessible	0 – Possibly implementable
		Readily Accessible	✓ – Implementable
	Alternative Characteristics	Technical Implementability	X - Likely not implementable
		Availability of Remedial Resources	0 – Possibly implementable
		Ability to Obtain Regulatory Approvals	XX - Not Implementable
Cost	Relative Cost		XX – Very high cost

<u>Evaluation</u>

Alternative 8 – Full-Depth Contaminated Sediment Removal without Backfill + MNR + ICs will not be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

Removal of soft sediment would effectively and permanently remove COPC mass from the BCSA. However, full-depth removal without backfill would result in the loss of marsh and wetland habitat areas and the creation of new open water. Depending on the size of the removal area, this could destabilize the adjacent marsh, adjacent waterway, and mudflats, and result in deleterious impacts on overall habitat. Restoration of the marsh habitat is not feasible without backfill. For these reasons the alternative is assessed to be likely not effective for low risk and high stability areas. As previously noted, there are no low stability areas within the marshes. For high-risk areas, removal without backfill is assessed to be possibly effective at reducing COPC concentrations and potential risks, but the noted drawbacks remain.

Removal alternatives require more transportation of equipment and materials than other alternatives, so these alternatives are rated Possibly Implementable for areas with limited access. Transportation of equipment into and out of readily accessible areas poses challenges but is assessed to be implementable.

Full-Depth Contaminated Sediment Removal without Backfill in the wetlands would require consideration of permit equivalencies related to NJDEP and USACE wetlands requirements, including those related to impact avoidance, minimization, and compensatory mitigation. Destruction of habitat is the least-favored alternative under USACE wetlands permitting policy (EPA, 1990). Removal alternatives have a higher likelihood of habitat damage and destruction as compared to non-removal alternatives. Since this alternative does not include backfilling, it would result in the greatest habitat loss and damage.

The cost of full-depth removal without backfill over a significant portion of the Site is very high.

6.7.9 Alternative 9 – Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs

Effectiveness	Area Risk	Lower Risk	X – Likely not effective
		Higher Risk	✓ – Effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	X – Likely not effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	0 – Possibly effective
Implementability	Area Accessibility	Less Accessible	0 – Possibly implementable
		Readily Accessible	✓ – Implementable
	Alternative Characteristics	Technical Implementability	X - Likely not implementable
		Availability of Remedial Resources	0 – Possibly implementable
		Ability to Obtain Regulatory Approvals	0 – Possibly implementable
Cost	Relative Cost		XX – Very high cost

<u>Evaluation</u>

Alternative 9 – Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

The benefits and limitations described under Alternative 7 also apply to Alternative 9. Alternative 9 would effectively and permanently remove a larger mass of COPCs than other alternatives. However, this alternative requires removal to greater depths and volumes and correspondingly longer implementation timeframes. These factors potentially increase the short-term risks compared to Alternative 7. Backfilling would potentially mitigate some of the short-term risks associated with residuals. In areas with higher risk or lower natural recovery, the long-term benefits may outweigh the short-term risks. In lower risk, higher recovery areas, the short-term risks may outweigh the long-term benefits and reduce the relative effectiveness of this alternative.

Sediment removal with backfilling in the wetlands would require consideration of permit equivalencies related to NJDEP and USACE wetlands requirements, including those related to impact avoidance, minimization, and compensatory mitigation. Destruction of habitat is the least-favored alternative under USACE wetlands permitting policy (EPA, 1990). Removal alternatives have a higher likelihood of habitat damage and destruction as compared to non-removal alternatives.

The cost of full-depth contaminated sediment removal with backfill is considered very high compared to other alternatives and is higher than Alternative 7.

6.7.10 Alternative 10 – Hydraulic/Hydrologic Controls + MNR + ICs

Effectiveness	Area Risk	Lower Risk	✓ – Effective
		Higher Risk	0 – Possibly effective
	Area Stability	Lower Stability	NA – Not applicable
		Higher Stability	✓ – Effective
	Natural Recovery	Lower NR	✓ – Effective
		Higher NR	0 – Possibly effective
Implementability	Area Accessibility	Less Accessible	✓ – Implementable
		Readily Accessible	✓✓ – Highly implementable
	Alternative Characteristics	Technical Implementability	0 – Possibly implementable
		Availability of Remedial Resources	✓✓ – Highly implementable
		Ability to Obtain Regulatory Approvals	✓ – Implementable
Cost	Relative Cost		✓ – Low cost

<u>Evaluation</u>

Alternative 10 – Hydraulic/Hydrologic Controls + MNR + ICs will be retained as an alternative for consideration in the detailed remedial alternatives evaluation.

Hydraulic/hydrologic controls can be designed to encourage natural recovery through deposition of cleaner sediments and/or to reduce potential exchange from impacted areas to unimpacted areas. Hydrologic and sediment balances would need to be carefully considered to avoid potential adverse effects such as insufficient sediment delivery or inundation frequency to maintain marsh and waterway stability. Hydraulic and hydrodynamic controls are most effective in areas with low risks and low natural recovery. The specific hydraulic or hydrodynamic control technologies would need to be selected and designed for area-specific conditions.

This alternative is rated possibly effective in higher risk areas since the same mechanisms that would encourage natural recovery in low-risk areas would apply, but higher risk areas my require longer timeframes to achieve RAOs. The hydraulic/hydrologic controls can be designed to enhance cleaner sediment deposition in lower natural recovery areas; thus it is evaluated to be effective in lower natural recovery areas.

Depending on the scale of selected hydraulic/hydrologic controls, the structures may be relatively small in size (e.g., if targeting marsh tributaries), so limited amounts of material and equipment may need to be transported to and from the work area. However, if larger scale controls are considered, less accessible areas would pose challenges.

Anticipated hydraulic/hydrologic controls include active control weirs or tide gates, marsh channel realignment, storm drain realignment, and tide gates. These are all commonly applied technologies that employ readily available equipment. However, due to the challenges related to hydrology and sediment balance described above, this alternative is rated as possibly implementable.

Hydraulic/hydrologic controls would require consideration of permit equivalencies related to NJDEP and USACE wetlands requirements, including those related to impact avoidance, minimization, and compensatory mitigation. However, it is anticipated that the project could meet these types of regulatory requirements.

This alternative may also be a component of other remedial alternatives.

This alternative is assessed to be low cost, although the associated costs are anticipated to be higher than MNR + ICs alone.

6.8 Conclusions and Summary

Nine remedial alternatives were identified for the waterways and ten alternatives were identified for the marshes. Eight waterway and nine marsh alternatives will be carried forward to the detailed alternatives evaluation. The alternative that was not retained for both waterways and marshes is Alternative 8 – Full-Depth Contaminated Sediment Removal (without Backfill) although there may be applications for this alternative as a component of a combined alternative depending on location-specific conditions.

Overall, less intrusive alternatives (MNR and EMNR alternatives) are rated higher in effectiveness in higher stability, lower risk, and higher natural recovery areas. More intrusive alternatives (removal and capping alternatives) are rated higher in higher risk and lower stability areas. A primary consideration in evaluating less intrusive alternatives is their ability to achieve RAOs in an acceptable time frame. A primary concern for the more intrusive alternatives is preserving waterway and marsh stability and restoring ecological habitat while achieving RAOs.

SECTION 7

APPROACH TO DETAILED ALTERNATIVES ANALYSIS

7.1 Basis for the Planned Detailed Alternatives Analysis Approach

Consistent with the FS scoping in the RI/FS Work Plan, the next step in the FS process following the DSRAM will be the detailed alternatives analysis. The detailed alternatives analysis will be completed for the tidal portion of the BCSA watershed taking into account the following key factors and considerations:

- The BCSA is an urban watershed. The urban setting has a profound influence on the physical, chemical, and biological characteristics of BCSA, which are distinctly different than non-urban areas.

- The BCSA is a stable tidal area landscape. Stable geomorphology/landforms are present throughout the majority of the BCSA. The *Phragmites* marshes are a key factor contributing to long-term system stability and resiliency to mitigate the impacts of storms and flood events. The dense stands of *Phragmites* also present a physical barrier that limits human activity and potential exposure in the marshes.

- Disturbance or alteration of *Phragmites* marshes can affect system stability. Past efforts to establish alternate vegetative communities within BCSA have failed (i.e. Berry's Creek Marsh). As a consequence, these mitigation efforts have resulted in a localized destabilization of the marsh with extensive open water and mudflats.

- Natural conditions in the fringing marsh system sequester COPCs and reduce bioavailability in sediment and surface water.

  - BCSA is net depositional, resulting in burial and isolation of the highest concentrations of COPCs. These conditions support natural recovery in the marshes and portions of the waterways. COPC concentrations are generally lower at the sediment surface and are substantially higher at depth. This pattern is observed throughout the study area in marshes and the majority of the waterways. Variations to this pattern are localized and their bases understood.

  - Physical and chemical sequestration processes operate to limit COPC bioavailability. The majority of mercury in sediment is present in low mobility/bioavailability fractions. Net methylation of mercury in the BCSA is comparable to levels measured at sites with much lower total mercury concentrations in various media.

- COPC concentrations are substantially higher in the northern half of study area in all sampled media**.** Methyl mercury shows a similar gradient to other COPCs, but is less distinct. There is a distinct difference between COPC concentrations in sediment, surface water, and biota observed in UBC/MBC and those found in LBC/BCC. COPC concentrations in LBC/BCC are generally more similar to the broader regional conditions and reference area COPC concentrations.

- Other considerations related to the detailed alternatives analysis include land planning initiatives related to flood mitigation and control such as The New Meadowlands Concept Plan commissioned by Rebuild-by-Design and prepared by the Massachusetts Institute for Technology (MIT) and the MIT Center for Advanced Urbanism (CAU) (MIT CAU, 2014) will likely influence the overall meadowlands setting, including the BCSA. Flood mitigation projects or structures could result in changes to the system hydrology, energy and sediment transport properties. These initiatives and plans will be monitored and will need to be considered in the alternatives analysis process.

7.2 Planned Approach to the Detailed Alternatives Analysis

Overall, the Group will conduct a detailed analysis of remedial alternatives in accordance with CERCLA guidance (EPA, 1988) and the AOC SOW. This work will be conducted in accordance with the approved RI/FS Schedule. A presentation of the detailed alternatives analysis to the EPA will occur prior to the preparation of the FS document.

The comparative analysis of remedial alternatives will apply the first seven CERCLA evaluation criteria to the assembled remedial alternatives to ensure that the selected remedial alternative would be protective of human health and the environment; would be in compliance with ARARs (or identify where waivers would be required); would be cost-effective; would utilize permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practicable; and would address the statutory preference for treatment as a principal element. The evaluation criteria are listed below:

1. Overall protection of human health and the environment

2. Compliance with ARARs

3. Long-term effectiveness and permanence

4. Reduction of toxicity, mobility, or volume

5. Short-term effectiveness

6. Implementability

7. Cost

The eighth and ninth criteria (Modifying Criteria), (8) State (or support agency) acceptance and (9) Community acceptance, would be considered by EPA after the RI/FS Report and Proposed Plan are released to the general public for comment.

To perform the detailed alternatives analysis, subareas within the BCSA will be identified as SMUs and alternatives or combinations of alternatives will be evaluated for the SMUs in consideration of area-specific conditions. The SMUs will be defined to represent areas of similar site characteristics, impacts, exposure pathways and receptors based on RI findings and the baseline risk assessment. The SMUs dimensions and distinguishing factors will evolve over the course of the completion of the RI/FS. The SMU-based approach is consistent with the EPA’s Contaminated Sediment Remediation Guidance (EPA, 2005) and the AOC SOW.

In recognition of the large size of the BCSA, the multiple current and past sources of stressors, and likelihood of a long period of remedy implementation and monitoring, the SOW for the BCSA AOC calls for the consideration of an ASM approach to the remedy. This is consistent with EPA’s Sediment Guidance (EPA, 2005) that recommends the application of ASM at complex sediment sites to provide additional certainty and information to support decisions.

The range of site conditions (i.e., morphological features, COPC concentrations, type of receptors) supports application of a range of technologies to areas of the BCSA where risk reduction is warranted. This process will include system-wide analyses to consider the interaction of waterways and marshes and the interconnection of these features throughout the BCSA system. Management decisions for one component of the BCSA will require consideration of the effects on other system components. ASM would facilitate a remedial approach that allows the remedial process to be effectively sequenced and tailored to the BCSA conditions. The effectiveness of initial remedial measures would be monitored and progress toward the RAOs evaluated. As necessary, adaptive components of the remedy would be optimized and implemented to improve remedial effectiveness while reducing potential negative outcomes. For example, initial remedial measures conducted in a waterway or portion of the BCSA may be sufficient to not only reduce risks within the remediated area, but may be sufficient to facilitate and encourage natural recovery of other areas by managing potential sources for COPC redistribution. Adaptively managing the remedial actions would avoid disturbances and other potential negative consequences associated with remedial measures or adaptive components that are determined not to be necessary or that can be optimized.

One of the tools that may be used to semi-quantify professional opinions and add transparency as well as objectivity to the detailed alternatives evaluation is a tabular rating system for each alternative compared to the CERCLA criteria. Best professional judgment in conjunction with relevant guidance materials and literature would be used in assigning points. If used, the rating form and numerical scoring process will be developed and presented to the EPA in a work session. It will be fashioned from other similar rating forms and approaches to comparative alternative analyses to provide for an evaluation that is sufficiently detailed to distinguish among the alternatives. This process is consistent with EPA Sediment Guidance (EPA, 2005).

The CERCLA criteria evaluation will also incorporate consideration of GSR-based evaluation of the advantages and disadvantages of alternatives and the balancing of the various risks, costs and benefits of each alternative. Consistent with GSR, the evaluation considers broader environmental effects within the framework of the NCP in order to optimize the net environmental benefits of the alternatives. The GSR approach also identifies opportunities for engaging stakeholders (e.g., municipalities and non-governmental organizations [NGOs]) and addressing stakeholder needs in the remedial processes, resource management, and planning goals. The GSR approach has been recently endorsed for the CERCLA FS process (ITRC 2011, NAVFAC 2012a & b, NRC 2011, NRC 2014, USACE 2012, and EPA 2010). In addition, it is consistent with USEPA's Sediment Management Principle 7 (Select site-specific, project-specific and sediment-specific risk management approaches that would achieve risk-based goals) and Principle 10 (Design remedies to minimize short-term risks while achieving long-term protection) (EPA, 2005). Both of these principles of managing contaminated sediments emphasize the importance of a holistic evaluation of environmental trade-offs in the remedy evaluation process.

The results of the detailed alternatives analysis will be presented in a Draft Feasibility Study Report that will be submitted to EPA.

SECTION 8

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Tables

Table 1-1: Estimated Areas[1] by Geomorphological Feature, Berry's Creek Study Area

Study Area	Mudflats	Waterway Channel (Area)	Waterway Primary Channel Length (Miles)	Marshes[2]
Upper Berry's Creek	14.4	9.7	1.5	133.0[3]
Middle Berry's Creek	10.4	33.0	1.6	213.3
Lower Berry's Creek	27.2	26.9	2.3	447.0
Berry's Creek Canal	8.9	29.9	1.2	78.7
Total	**60.9**	**99.5**	**6.6**	**872**

Note: 1. All area measurements are presented in acres.
2. Presented marsh areas include tributaries and pools.
3. Includes Upper Peach Island Creek Marsh above tide gate.

Table 3-1: Preliminary Identification of Location Specific Federal and State ARARs and TBCs, Berry's Creek Study Area Feasibility Study

Potential Applicable Relevant and Appropriate Requirements and TBCs	Description	ARAR or TBC	Comment
Floodplain Management 40 CFR Part 6, Appendix A, §3b	Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain.	ARAR	Applicable to the extent that remedial action involves potential effects on floodplains.
Wetlands Protection 40 CFR Part 6, Appendix A, §3c	Under this Order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. If remediation is required within wetland areas and no practical alternative exists, potential harm must be minimized and the agency must act to restore and preserve the wetlands' natural and beneficial values.	ARAR	Applicable to the extent that remedial action involves potential effects on wetlands.
FISH AND WILDLIFE COORDINATION ACT			
Fish and Wildlife Coordination Act 16 USC §662	Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose, by any department or agency of the United States, such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State in which the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.	ARAR	Applicable if remedial action involves controlling or modifying a body of water.
MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT			
Public Law 94-265, as amended through Oct. 11, 1996	Requires that federal agencies consult with National Marine Fisheries Service on actions that may adversely affect essential fish habitat, defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."	ARAR	Applicable if relevant fishery council has designated any portion of the Berry's Creek Study Area as essential fish habitat ("EFH"). A preliminary review of EFH using the National Marine Fisheries Service's EFH Mapper indicates that the Berry's Creek Study Area does not contain EFH.
ENDANGERED SPECIES			
Endangered Species Act of 1973 as amended 16 U.S.C. §§1530–1544 50 CFR Part 17, Subpart I; Part 402	Requires federal agencies to verify that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of a critical habitat of such species, unless such agency has been granted an appropriate exemption by the Endangered Species Committee (16 U.S.C. § 1536).	ARAR	Applicable if endangered species present at Berry's Creek Study Area.
New Jersey Endangered Species Conservation Act N.J.S.A. 23:2A N.J.A.C. 7:5C	Prohibits the unauthorized taking of endangered wildlife.	ARAR	Applicable if listed species present at Berry's Creek Study Area.
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION			
Flood Hazard Area Program N.J.A.C. 7:13	Program incorporates more stringent standards for regulated activities (including remedial action) in flood hazard areas and riparian zones adjacent to surface waters throughout the State. The Department has adopted these new rules in order to better protect the public from the hazards of flooding, preserve the quality of surface waters, and protect the wildlife and vegetation that exist within and depend upon such areas	ARAR	Substantive standards applicable if remedial action occurs in flood hazard areas and riparian zones.

Table 3-1: Preliminary Identification of Location Specific Federal and State ARARs and TBCs, Berry's Creek Study Area Feasibility Study

Potential Applicable Relevant and Appropriate Requirements and TBCs	Description	ARAR or TBC	Comment
	for sustenance and habitat.		
Freshwater Wetlands Protection Act N.J.A.C. 7:7A	Regulates all dredging and sediment disturbance or removal activities in freshwater wetlands.	ARAR	Substantive standards applicable if remedial action requires any disturbances of freshwater wetlands.
New Jersey Coastal Zone Management N.J.A.C. 7:7E	Provides rules and standards for any development, including sediment removal and fill, at or below mean high water line of all coastal and tidal waters, up to 500 feet from the mean high water of coastal and tidal waters, in all areas containing tidal wetlands, and in the Hackensack Meadowlands District.	ARAR	Substantive standards applicable if remedial action involves construction, sediment removal, or fill in governed areas.
New Jersey Meadowlands Commission N.J.A.C. 19:3–4	Regulates all activities in the Hackensack Meadowlands District. Contains performance standards regarding wastewater, hazardous substances, noise, and vibrations.	ARAR	Performance standards for land uses vary with zoning districts.
HISTORIC PRESERVATION			
National Historic Preservation Act 16 U.S.C. § 470 et seq. 36 CFR Part 800	Establishes procedures to provide for preservation of scientific, historical, and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. If scientific, historical, or archaeological artifacts are discovered at the site, work affected by such discovery will be halted pending the completion of any data recovery and preservation activities required pursuant to the Act and its implementing regulations. New Jersey administers this program within the state and has integrated the New Jersey Register of Historic Places program with the National Register Program.	ARAR	Applicable if any part of BCSA listed or eligible for listing in the National Register Of Historic Places. Potentially applicable during remedial activities if scientific, historic, or archaeological artifacts are identified during implementation of the remedy. As part of the Phase 1 Remedial Investigation, a Cultural Resources Survey was conducted and the results of this survey will be considered in the analysis of this ARAR.
New Jersey Register of Historic Places Act N.J.S.A. 13:1B-15.128 et seq N.J.A.C. 7:4	The New Jersey Register of Historic Places Act requires that actions by state, county, or local governments, which may impact a property listed in the New Jersey Register of Historic Places, be reviewed and authorized through the Historic Preservation Office ("HPO"). The HPO also provides advice and comment for a number of permitting programs within the Department of Environmental Protection.	ARAR	Applicable if any part of BCSA is listed in the New Jersey Register Of Historic Places. Potentially applicable during remedial activities if scientific, historic, or archaeological artifacts are identified during implementation of the remedy. As part of the Phase 1 Remedial Investigation, a Cultural Resources Survey was conducted and the results of this survey will be considered in the analysis of this ARAR.
OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE (OSWER)			
OSWER Directives 9280.0	Policy on Floodplain and Wetlands Assessments for CERCLA Actions	TBC	Provides policy on considering wetlands and floodplains at CERCLA Sites.

Notes: 1. ARARs = Applicable or Relevant and Appropriate Requirements.
2. TBC = To be Considered information.

Table 3-2: Preliminary Identification of Action Specific Federal and State ARARs and TBCs, Berry's Creek Study Area Feasibility Study

Potential Applicable Relevant and Appropriate Requirements	Description	ARAR or TBC	Comment
CLEAN WATER ACT (CWA)			
Water Quality Certification CWA § 401	Requires any applicant for a federal license or permit which may result in a discharge into navigable waters to obtain certification of compliance with state effluent discharge standards.	ARAR	Substantive requirements applicable if remedial action involves discharges to navigable waters.
National Pollutant Discharge Elimination System CWA § 402 40 CFR Parts 122, 401	Regulates discharges of pollutants into navigable waters.	ARAR	Substantive requirements applicable if remedial action involves discharges to surface water or groundwater. No permit required if remedial action is conducted entirely onsite.
Federal Ambient Water Quality Criteria CWA § 304(a)	Requires EPA to establish ambient water quality criteria that will be used by states as guidance for state water quality standards.	ARAR	Along with State water quality standards, AWQC may be ARAR to set limits for remedial action discharges to surface water or groundwater.
Guidelines for Specification of Disposal Sites for Dredged or Fill Material CWA §404 40 CFR Part 230	Regulates the discharge of dredged or fill material into the waters of the U.S., including wetlands.	ARAR	Substantive requirements applicable if remedial action involves dredging or filling. No permit required if remedial action is conducted entirely onsite.
Compensatory Mitigation for Losses of Aquatic Resources 40 CFR §§ 230.91–.98	In the event of wetland removal or filling, compensatory mitigation needed to offset unavoidable adverse impacts to wetlands, streams, and other aquatic resources is required and will be included in Clean Water Act Section 404 permits and other applicable Department of the Army permits.	ARAR	Applicable if remedial action involves removal or filling of wetlands.
TOXIC SUBSTANCES CONTROL ACT OF 1976			
15 U.S.C. §§ 2601 et seq. 40 CFR Part 761 Subpart D	Regulates disposal of PCB remediation waste.	ARAR	Applicable if remedial action involves removal and disposal of sediment that is classified as PCB remediation waste.
MERCURY EXPORT BAN ACT			
Public Law 110-414 (122 STAT. 4341–4348)	Establishes export and resale ban of elemental mercury containing materials. Remediation waste may be exported for treatment/disposal but not for sale or reuse of any recovered mercury.	ARAR	Applicable if remedial action involves removal and potential sale or reuse of medium containing mercury.
RESOURCE CONSERVATION AND RECOVERY ACT OF 1976 (RCRA)			
40 CFR Parts 260-268: Off-site Land Disposal, Subtitle C	Soil and/or sediment that is excavated for off-site disposal and constitutes a hazardous waste must be managed in accordance with the requirements of RCRA.	ARAR	Applicable if remedial action involves off-site disposal of hazardous waste.

Table 3-2: Preliminary Identification of Action Specific Federal and State ARARs and TBCs, Berry's Creek Study Area Feasibility Study

Potential Applicable Relevant and Appropriate Requirements	Description	ARAR or TBC	Comment
40 CFR Part 258: Off-site Land Disposal, Subtitle D	Criteria for Municipal Solid Waste Landfills, establishes requirements for the operation of landfills accepting non-hazardous solid waste.	ARAR	Applicable if remedial action uses facilities for the disposal of non-hazardous soil and/or sediment.
40 CFR 261, Subparts C and D: Standards Applicable to Generators of Hazardous Waste: The Manifest, Pre-transport Requirements, Record Keeping and Reporting		ARAR	Applicable if remedial action involves off-site disposal of hazardous waste.
49 CFR 172, 173, 178 and 179: Department of Transportation Requirements for Packaging, Labeling and Marking Hazardous Waste for Transport	Transportation of hazardous materials on public roadways must comply with the requirements.	ARAR	Applicable if remedial action involves off-site disposal of hazardous waste.
OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA)			
29 CFR Part 1910: Occupational Safety And Health Standards	Requirements for worker safety	ARAR	
29 CFR Part 1926: OSHA Safety and Health Standards for Construction	Requirements for worker safety during construction	ARAR	
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION			
New Jersey Water Pollution Control Act N.J.S.A. 58:10A et seq. New Jersey Pollutant Discharge Elimination System (NJPDES) N.J.A.C. 7:14A	Prohibits all unpermitted discharges into surface and ground waters, pursuant to federal and New Jersey law. Establishes effluent discharge standards to protect water quality. Specifically, NJAC 7:14A-12.11(d) and -12 Appendix B provide toxic effluent standards for site remediation projects.	ARAR	Substantive requirements applicable if remedial action involves discharges to surface or groundwater. No permit required if remedial action is conducted entirely onsite.
Surface Water Quality Standards N.J.A.C. 7:9B	Establishes the designated uses and antidegradation categories of the State's surface waters, classifies surface waters based on those uses (i.e., stream classifications), and specifies the water quality criteria and other policies and provisions necessary to attain those designated uses.	ARAR	Applicable if remedial action involves discharges to surface water.[1]
Ground Water Quality Standards N.J.A.C. 7:9C	Establishes the designated uses and water quality standards for the State's ground waters.	ARAR	Applicable if remedial action involves discharges to ground water.
New Jersey Solid Waste Management Act, N.J.S.A. §13:1E-1, et seq., New Jersey Solid and Hazardous Waste Rules, N.J.A.C. 7:26, 7:26B and 7:26G	Establishes requirements for generators, transporters and facilities that manage solid waste and hazardous waste, and for thermal destruction facilities.	ARAR	Applicable if remedial action involves on-site disposal facility.

[1] In 2001, EPA published a methylmercury criterion based on tissue sampling methodologies and data on human exposure to mercury. EPA, *Water Quality Criterion for the Protection of Human Health: Methylmercury*, EPA-823-R-01-001 (2001); 66 Fed. Reg. 1344 (Jan. 8, 2001). This approach is expressed as a fish and shellfish tissue value rather than as a water column value. In the event that the remediation action involves discharges to surface waters, the federal criterion for methylmercury may be more relevant and appropriate than the current New Jersey mercury standard.

Table 3-2: Preliminary Identification of Action Specific Federal and State ARARs and TBCs, Berry's Creek Study Area Feasibility Study

Potential Applicable Relevant and Appropriate Requirements	Description	ARAR or TBC	Comment
New Jersey Noise Control N.J.S.A. § 13:1g-1 et seq. N.J.A.C. 7:27	Regulates noise levels for certain types of activities and facilities such as commercial, industrial, community service and public service facilities.	ARAR	
RIVERS AND HARBORS ACT OF 1899			
33 U.S.C. §§ 401–403. Dredging in Navigable Waters of the US 33 CFR Part 322	Requires approval from United States Army Corps of Engineers (USACE) for dredging and filling work performed in a navigable waterway of the US. Activities that could impede navigation and commerce are prohibited.	TBC	Substantive requirements applicable if remedial action impedes navigable water. No permit required if remedial action is conducted entirely onsite.
U.S. ENVIRONMENTAL PROTECTION AGENCY			
Treatment Technologies for Mercury in Soil, Waste, and Water (EPA 2007)	Mercury treatment for disposal or site specification. As a technology overview document, the report is intended to be used as a screening tool for mercury treatment technologies and the information can serve as a starting point to identify options for mercury treatment.	TBC	
U.S. ARMY CORPS OF ENGINEERS GUIDANCE ON CONFINED DISPOSAL FACILITIES			
Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities — Testing Manual. U.S. Army Corps of Engineers January 2003	On-site confined disposal; Provides technical guidance for evaluation of potential contaminant migration pathways from confined disposal facilities (CDFs) and provides the best available technical guidance regarding how dredged material proposed for placement in CDFs should be evaluated and/or tested.	TBC	
OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE (OSWER)			
OSWER Directive 9200.1-90	EPA Contaminated Sediment Directive (Response to Regional Request Regarding Sediment Cleanup at May 2008 Superfund Division Directors Meeting)	TBC	
OSWER Directive 9285.6-08	Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites; Letter Response to Regional Request Regarding Sediment Cleanup at May 2008 Superfund Division Directors Meeting. EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) believes that dredging, while not a presumptive remedy, should be considered on an equal footing with other remedial options. The most appropriate remedy for a site, which may include dredging for all or part of the site, should be chosen after considering site-specific data and the National Oil and Hazardous Substances Pollution Contingency Plan's (NCP's) nine remedy selection criteria.	TBC	

Notes: 1. ARARs = Applicable or Relevant and Appropriate Requirements.
2. TBC = To be Considered information.

Table 3-3: Preliminary Identification of Chemical Specific Federal and State ARARs and TBCs, Berry's Creek Study Area Feasibility Study

Potential Applicable or Relevant and Appropriate Requirements and TBCs	Description	ARAR or TBC	Comment
Water Quality Management Planning Act N.J.S.A. 58:11A et seq. N.J.A.C. 7:15	Provides the basic policy direction for WQM planning in the New Jersey Coastal Zone defined at including, but not limited to, the Hackensack Meadowlands District	TBC	Establishes policies, procedures and standards which, wherever attainable, help to restore, enhance and maintain the chemical, physical and biological integrity of the waters of the State, including ground waters, and the public trust therein, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial and other uses of water.

Notes: 1. ARARs = Applicable or Relevant and Appropriate Requirements.
2. TBC = To be Considered information.

Table 4-1: General Response Actions, Berry's Creek Study Area

General Response Action	Description
No Action	CERCLA required alternative; does not need to be evaluated.
Institutional Controls (IC)	Institutional controls are administrative mechanisms to protect human health. Examples of ICs include fish consumption alerts, and restrictions on on-site activities such as recreational use of waterways. In the marsh areas ICs may include fencing.
Monitored Natural Recovery (MNR)	The National Research Council (NRC) defines MNR as a practice that "relies on un-enhanced natural processes to protect human and environmental receptors from unacceptable exposures to contaminants" (NRC 2000). MNR mechanisms include burial through deposition of cleaner sediment as well as transformation of COPCs. MNR relies on physical, chemical, and biological processes to isolate, destroy, or otherwise reduce exposure to or toxicity of contaminants in sediment (USEPA 2005a, NRC 1997) to achieve site-specific remedial action objectives (RAOs). These processes may include biodegradation, biotransformation, bioturbation, diffusion, dilution, adsorption, volatilization, chemical reaction or destruction, resuspension, and burial by clean sediment. Significant areas within the BCSA are naturally recovering through burial.
Enhanced MNR	Enhanced MNR (EMNR) involves the active application of a technology to expedite or enhance the occurring natural recovery of a system. The goal of Enhanced MNR is to expedite the natural recovery and thus achieve RAOs in a reduced timeframe from the MNR period. Relevant examples of Enhanced MNR include thin-layer placement of material, thin-layer placement with amendments, or addition of in situ treatment amendments.
Containment	Containment involves capping of impacted sediment to isolate the COPCs from ecological or human receptors. Containment is applied when COPCs are left in place, i.e., containment would be used in lieu of complete removal.
Removal	Removal is the excavation of impacted material to reduce risk to ecological or human receptors. Removal includes excavation or dredging of impacted sediments and would include a disposal component. Removal can be a total removal or a partial removal of impacted material with a containment component.

Table 5-1: Identified Remedial Alternatives by General Response Action, Berry's Creek Study Area

General Response Action	Identified Alternatives
No Action	• Alternative 1 - No Action
Institutional Controls (IC)	• Alternative 2 – Institutional Controls (ICs) (alone)
Monitored Natural Recovery	• Alternative 3 - Monitored Natural Recovery (MNR) + ICs
Enhanced Monitored Natural Recovery	• Alternative 4 - Direct Application of Treatment Amendment + MNR + ICs • Alternative 5 - Thin-Layer Placement + MNR + ICs • Alternative 6 - Thin-Layer Placement with Amendment + MNR + ICs
Capping/Removal	• Alternative 7 - Partial Contaminated Sediment Removal + Capping + MNR + ICs
Removal	• Alternative 8 - Full-Depth Contaminated Sediment Removal (without Backfill) + MNR + ICs • Alternative 9 - Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs
Not classified under a GRA	• Alternative 10 - Hydraulic/Hydrologic Controls + MNR + ICs (marshes only)

Table 5-2: Waterway Alternatives, Berry's Creek Study Area

Alternative		Alternative Summary
1.	No Action	• CERCLA mandated alternative.
2.	Institutional Controls (ICs) (Alone)	• For waterways ICs could consists of continuation of fish consumption advisories, and implementation of waterway use restrictions (e.g., No Swimming, No Fishing Signage, No Wake/Disturbance Zones). • ICs do not include monitoring and documenting the progress of natural recovery, and ICs could be adjusted over time as the system improves.
3.	Monitored Natural Recovery (MNR) + ICs	• The alternative relies on natural processes (e.g., transformation, immobilization, isolation) to achieve acceptable risk levels that protect human health and ecological receptors. • MNR includes periodic field monitoring events to document the recovery progress, as well as ICs to protect human health during the recovery. • MNR could be implemented as an Adaptive Site Management (ASM) approach. Thus in areas where the rate of recovery is observed in the future to be lower than anticipated, more intrusive remedies could be implemented to enhance the recovery and reduce risks.
4.	Direct Application of Treatment Amendment + MNR + ICs	• The alternative consists of application of amendments on the surface of the bed sediment and allowing mixing into the surficial layer through natural processes or mechanical mixing. Bioavailability could be reduced without creating a new surface layer. • As demonstrated in site-specific treatability studies, amendments can successfully sequester COPCs and alter the chemical conditions to reduce the bioavailability. • Direct application of amendments is combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
5.	Thin-Layer Placement + MNR + ICs	• The alternative involves the placement of 6 inches or less of clean sand and/or sediment onto the waterway sediment bed. • Thin-layer placement is not intended to provide complete isolation of impacted sediment as in a conventional capping operation; instead it is designed to provide an immediate reduction in surficial sediment concentrations that facilitates the recovery and re-establishment of benthic organisms. • Thin-layer placement is combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
6.	Thin-Layer Placement with Amendment + MNR + ICs	• Thin-layer placement with amendment involves placing 6 inches or less of clean sand and/or sediment onto the waterway sediment bed with amendments incorporated as an additional layer or as a mixture. • While a thin-layer of clean material provides an immediate reduction in surficial sediment, amendments incorporated into the thin-layer placement would further sequester the COPCs and reduce the bioavailability. • Thin-layer placement with amendments is combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	• Partial removal and capping involves the removal of the upper layers of impacted sediment from designated areas and placement of a sufficiently thick clean layer of sand or other appropriate material as an engineered cap to isolate impacted sediment. • The alternative would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
8.	Full-Depth Contaminated Sediment Removal + MNR + ICs	• Full-depth removal involves the removal of soft sediments underlying the BCSA down to native Pleistocene clays or alternatively to a depth where unacceptable risks are addressed to achieve RAOs with no further remedial activity. • The alternative would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
9.	Full-Depth Contaminated Sediment Removal + Backfill + MNR + ICs	• Full-depth removal and backfill combines Alternatives 7 and 8 and is intended to remove soft sediments down to Pleistocene clays or alternatively to a depth where unacceptable risks are addressed to achieve RAOs and to backfill at least part of the removed sediment thickness. • The alternative would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.

Table 5-3: Marsh Alternatives, Berry's Creek Study Area

Alternative		Alternative Summary
1.	No Action	• CERCLA mandated alternative.
2.	Institutional Controls (ICs)	• For marshes, ICs could consist of implementation of marsh disturbance and access restrictions (e.g., Signage and Deed Restrictions). • ICs do not include monitoring and documenting the progress of natural recovery, and ICs could be adjusted over time as the system improves.
3.	Monitored Natural Recovery (MNR) + ICs	• The alternative relies on natural processes (e.g., transformation, immobilization, isolation) to achieve acceptable risk levels that protect human health and ecological receptors. • MNR includes periodic field monitoring events to document the recovery progress, as well as ICs to protect human during the recovery. • MNR could be implemented as an Adaptive Site Management (ASM) approach. Thus in areas where the rate of recovery is observed in the future to be lower than anticipated, more intrusive remedies could be implemented to enhance the recovery and reduce risks.
4.	Direct Application of Treatment Amendment + MNR + ICs	• The alternative consists of application of amendments on the surface of the marsh and allowing mixing into the surficial layer through natural processes. Bioavailability could be reduced without creating a new surface layer. • As demonstrated in site-specific treatability studies, amendments can successfully sequester COPCs and alter the chemical conditions to reduce the bioavailability. • Direct application of amendments would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
5.	Thin-Layer Placement + MNR + ICs	• The alternative involves the placement of 6 inches or less of clean sand and/or sediment onto the marsh surface. • Thin-layer placement is not intended to provide a complete isolation of impacted sediment as in a conventional capping operation; instead it is designed to provide an immediate reduction in surficial sediment concentrations that facilitates the recovery and re-establishment of benthic organisms. • Thin-layer placement would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
6.	Thin-Layer Placement with Amendment + MNR + ICs	• Thin-layer placement with amendment involves placing 6 inches or less of clean sand and/or sediment onto the marsh surface with amendments incorporated as an additional layer or as a mixture. • While a thin-layer of clean material provides an immediate reduction in surficial sediment, amendments incorporated into the thin-layer placement would further sequester the COPCs and reduce the bioavailability. • Thin-layer placement with amendments would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	• Partial removal and capping involves the removal of the upper layers of impacted sediment from designated areas and placement of a sufficiently thick clean layer of sand or other appropriate material as an engineered cap to isolate impacted sediment. • The alternative would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
8.	Full-Depth Contaminated Sediment Removal + MNR + ICs	• Full-depth removal involves the removal of soft sediments underlying the BCSA down to native Pleistocene clays or alternatively to a depth where unacceptable risks are addressed to achieve RAOs with no further remedial activity. • The alternative would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to minimize human health risks, while achieving the RAOs.
9.	Full-Depth Removal + Backfill + MNR + ICs	• Full-depth removal and backfill combines Alternatives 7 and 8 and is intended to remove soft sediments down to Pleistocene clays or alternatively to a depth where unacceptable risks are addressed to achieve RAOs and to restore at least part of the existing habitat. • The alternative would be combined with MNR, which will further reduce risk over time and will include monitoring to document the progress of recovery and ICs to

Table 5-3: Identified Marsh Alternatives, Berry's Creek Study Area

Alternative		Alternative Summary
		minimize human health risks, while achieving the RAOs.
10.	Hydraulic/Hydrologic Controls + MNR + ICs	• The Hydraulic/Hydrologic controls alternative involves modifications to the existing hydraulic conditions of the marshes via engineered structures or measures. The objective(s) are to enhance deposition of cleaner sediment that would facilitate recovery or induce flow and inundation patterns to mitigate COPC exchange from the marsh areas. • Potential Hydraulic/Hydrologic controls consist of installing self-regulating tidegates, rerouting tidal flow drainage channels from highly impacted to unimpacted areas, and diverting stormwater runoff to facilitate deposition of cleaner sediments. • Hydraulic/Hydrologic controls would be combined with MNR to document the progress of recovery and ICs to minimize human health risks while achieving the RAOs.

Table 6-1: Effectiveness Evaluation of the Waterway Alternatives, Berry's Creek Study Area

	Alternative	Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
1.	No Action	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	• CERCLA required alternative, no screening performed.
2.	Institutional Controls (ICs) (alone)	**0**	**XX**	**XX**	**0**	**XX**	**0**	• ICs alone will not be effective outside of low risk, highly stable areas that do not require monitoring. • ICs will not be effective for protection of ecological receptors except for ongoing natural recovery. • Effectiveness for human health risk reduction depends on the ICs being followed. • ICs are considered as part of subsequent alternatives.
	Comments/Notes							
3.	Monitored Natural Recovery + ICs	✓	**XX**	**XX**	✓	**0**	✓✓	• More effective in areas of lower risk. • More effective in areas with higher natural recovery occurring. • Not effective in areas of lower stability. • Effectiveness of MNR will be dependent on the implementation and effectiveness of the accompanying ICs.
	Comments/Notes		Longer timeframe for achieving RAOs unless recovery rate very fast.	Rate of MNR uncertain in lower stability areas.				
4.	Direct Application of Treatment Amendment + MNR + ICs	✓	**0**	**XX**	✓✓	**0**	✓✓	• Will not provide barrier for isolation. • Effective in areas of lower risk and higher stability and natural recovery. • Not effective in areas of lower stability. Stability is a potential concern in some subtidal areas during the application and up to the point of incorporation into the sediment. • More effective in areas with higher natural recovery occurring but still effective to a limited degree in areas of lower natural recovery because of treatment layer. • .
	Comments/Notes	Short term positive effects (i.e., reduced BAZ COPC concentrations) will be realized with the application of an amendment in the surface layer.	Single application may have limited long- term effect on higher COPC level areas. Multiple applications may be required to be effective.	Risk of applied amendment washing away.		Addition of amendments may enhance recovery by binding COPCs, even in low MNR areas.	Applied amendment enhances ongoing natural recovery.	
5.	Thin-Layer Placement + MNR + ICs	✓✓	**0**	**XX**	✓✓	**0**	✓✓	• Effective in areas of lower risk and higher stability. • Pilot studies have documented that thin-layer placement plots have remained stable and in place. • More effective in areas with higher natural recovery occurring but still effective to a limited degree in areas of lower natural recovery. • Not effective in areas of lower stability. • Pilot studies have demonstrated thin-layer placement has reduced BAZ COPC concentrations.
	Comments/Notes	Short term positive effects (i.e., reduced BAZ COPC concentrations) will be realized with thin-layer placement.	Longer timeframe for achieving RAOs.	Risk of thin-layer washing away.	Pilot studies have shown thin-layer has remained in place. Will have minimal impact on habitat.	Addition of a thin-layer may enhance recovery, even in low MNR areas.	Thin-layer placement enhances ongoing natural recovery.	

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-1: Effectiveness Screening of Waterway Alternatives, Berry's Creek Study Area

	Alternative	Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
6.	Thin-Layer Placement with Amendment + MNR + ICs	✓✓	0	XX	✓✓	✓	✓✓	• Effective in areas of lower risk and higher stability and natural recovery. • Will provide higher effectiveness in the short-term than Direct Application of Amendments and Thin-layer Placement w/o Amendments. • Pilot studies have documented that thin-layer placement plots have remained stable and in place. • More effective in areas with higher natural recovery occurring but still effective to a limited degree in areas of lower natural recovery. • Generally not effective in areas of lower stability. • Pilot studies have demonstrated thin-layer placement has reduced BAZ COPC concentrations.
	Comments/Notes	Short term positive effects (i.e., reduced BAZ COPC concentrations) will be realized sooner with thin-layer placement with amendment. This alternative combines the benefit of placement of clean materials on the surface with the additional benefit of amendments binding COPCs. The amendments may mitigate short-term risks related to sediment disturbance during placement.	Longer timeframe for achieving RAOs. Amendments could improve short-term effectiveness compared to Alts. 4 and 5 by binding COPCs.	Risk of thin-layer washing away.	Pilot studies have shown thin-layer has remained in place. Will have minimal impact on habitat.	Potential enhancement of natural recovery even for low MNR areas by combining thin-layer placement with a potentially COPC-binding amendment.	Thin-layer placement with amendment enhances ongoing natural recovery.	
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	0	✓	✓	0	✓	✓	• Effectively removes COPC mass from system. • Sediment removal will result in environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • Cap materials would help mitigate potential negative impacts. • Long-term benefits need to be balanced against short-term risks from removal activities (i.e., resuspension, release, and redistribution of COPCs from bedded sediments and the presence of residuals). • Large scale intrusive activity could destabilize adjacent areas (e.g., slope stability issues). Restoration of waterway channels and mudflat areas can be challenging and requires careful consideration of hydrodynamics and bed geomorphology to avoid destabilizing portions of the waterways or adjacent marshes.
	Comments/Notes	Short-term risks from removal activities (i.e., resuspension, release, and redistribution of COPCs from bedded sediments and the presence of residuals) potentially outweigh the long-term benefits.	The long-term benefits of removal would likely outweigh the increased short-term risks (i.e., resuspension, release and redistribution of COPCs from bedded sediments, and residuals), but the risks must be managed effectively.	The long-term benefits of removal will likely outweigh the increased short-term stability risks, but the risks must be managed effectively.	Limited additional long-term benefits to improving stability given risks of short-term damages due to potentially destabilizing, exposing, and redistributing higher concentration COPCs.			

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-1: Effectiveness Screening of Waterway Alternatives, Berry's Creek Study Area

Alternative		Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
8.	Full-depth Contaminated Sediment Removal (without Backfill) + MNR + ICs	**0**	✓	**XX**	**XX**	**XX**	**X**	• Effectively removes COPC mass from system. • Sediment removal will result in environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • Long-term benefits need to be balanced against short-term risks from removal activities (i.e., resuspension, release, and redistribution of COPCs from bedded sediments and the presence of residuals). • Large scale intrusive activity could destabilize adjacent areas (e.g., slope stability issues). • Removal without backfill may destabilize channels and marshes as new flow and sediment transport patterns become established. If performed on small scale or targeted areas, these issues may be less of a consideration.
	Comments/Notes	Short-term risks from removal activities (i.e., resuspension, release, and redistribution of COPCs from bedded sediments and the presence of residuals) likely outweigh the benefits.	The long-term benefits of removal will likely outweigh the increased short-term risks (i.e., resuspension, release and redistribution of COPCs from bedded sediments, and residuals), but the risks must be managed effectively	Removal without backfilling will very likely cause short- and long-term stability issues by altering the hydraulic and hydrodynamic processes, and destabilizing the waterway, mudflats, and adjacent marsh.	Removal without backfill would result in significant hydrodynamic changes to the work area and areas up and downstream. These changes may destabilize channels and marshes in a natural system as new flow and sediment transport patterns become established. If performed on small scale or targeted areas, these issues may be less of a consideration.	Removal without backfill will alter sediment deposition, and therefore natural recovery processes, in adjacent areas.	Removal without backfill will alter sediment deposition, and therefore natural recovery processes, in adjacent areas.	
9.	Full-depth Contaminated Sediment Removal + Backfill + MNR + ICs	**0**	✓	✓	**0**	✓	✓	• Effectively removes COPC mass from system. • Sediment removal will result in environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • Backfill materials would help mitigate potential negative impacts. • Long-term benefits need to be balanced against short-term risks from removal activities (i.e., resuspension, release, and redistribution of COPCs from bedded sediments and the presence of residuals). • Large scale intrusive activity could destabilize adjacent areas (e.g., slope stability issues). Restoration of waterway channels and mudflat areas can be challenging and requires careful consideration of hydrodynamics and bed geomorphology to avoid destabilizing portions of the waterways or adjacent marshes.
	Comments/Notes	Short-term risks from removal activities (i.e., resuspension, release, and redistribution of COPCs from bedded sediments and the presence of residuals) likely outweigh the benefits.	The long-term benefits of removal will likely outweigh the increased short-term risks (i.e., resuspension, release and redistribution of COPCs from bedded sediments, and residuals), but the risks must be managed effectively		Limited additional long-term benefits to improving stability given risks of short-term damages due to potentially destabilizing, exposing, and redistributing higher concentration COPCs.			

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-1: Effectiveness Screening of Waterway Alternatives, Berry's Creek Study Area

Notes:

1. Both short-term and long-term Effectiveness of alternatives are considered in the evaluation. The Effectiveness of alternatives is considered in relation to general categories of conditions such as Risk, Stability, and Natural Recovery conditions. Since specific SMUs are not identified at this time, the alternatives are evaluated for a broadly representative range of conditions in the BCSA. In the detailed evaluation stages of the Feasibility Study process; a given SMU can be compared to these conditions to identify the expected relative Effectiveness of an alternative to the specific conditions of that SMU. While there is a range of each of these general conditions within the BCSA, for the purposes of the DSRAM, each condition is broken down into two general ranges. How specific actual conditions may fall within these categories remains to be determined through the continued Remedial Investigation and Risk Assessment analysis.
2. Area Risk refers to the relative human health or ecological risk posed by an area based on Risk Assessment evaluations and is generally representative of the relative COPC concentration range (e.g. high, medium, low). The ranges of actual risks present in the BCSA remain to be determined as well as what specific conditions may be determined to represent higher or lower risk.
3. Area Stability refers to whether the physical, chemical and biological conditions within the area are likely to remain stable over time. Conditions such as physical makeup of the sediment, observed physical stability of sediment, geochronology, and hydrologic conditions would be considered to evaluate the stability of an area. Other conditions such as physical features (e.g., stormwater outfall discharge) would be considered in the stability evaluation of a given SMU.
4. Natural Recovery refers to whether near surface COPC concentrations are decreasing over time. This analysis considers multiple lines of evidence, but one primary consideration is whether there is indication of deposition of clean sediment as evidenced by bulk COPC concentrations in shallow sediments that are progressively lower over time compared to deeper sediment layers (in areas where there is elevated deeper COPC concentrations). Similarly, in areas with low concentrations in deeper sediment, shallow sediment concentrations that remain consistently low would be indicative of on-going natural recovery. Areas that are recovering naturally would have reduced risk over time even without remedial intervention.

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-2: Implementability Evaluation of Waterway Alternatives, Berry's Creek Study Area

	Alternative	Area Accessibility[1]		Alternative Characteristics[2]			Summary Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility: Availability of Remedial Resources[4]	Administrative Feasibility: Ability to Obtain Regulatory Approvals[5]	
1.	No Action	**NA**	**NA**	**NA**	**NA**	**NA**	• CERCLA required alternative, no screening performed.
2.	Institutional Controls (ICs) (alone)	✓✓	✓✓	✓✓	✓✓	✓✓	• Implementable – signage and advisories already exist within the BCSA.
	Comments/Notes						
3.	Monitored Natural Recovery + ICs	✓✓	✓✓	✓✓	✓✓	✓✓	• Access will not be an issue as no material is brought in or out. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes					Similar approaches have been approved at other sites.	
4.	Direct Application of Treatment Amendment + MNR+ ICs	✓	✓✓	✓✓	✓✓	✓✓	• Easier to implement in readily accessible areas. • More implementable than the removal alternatives in areas with limited access. • Laboratory treatability tests have shown amendments are likely effective; pilot studies incorporating amendments are ongoing and will provide additional data regarding amendment effectiveness. • Will have very limited to no impact on habitat. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Requires less transport and placement than removal alternatives. Limited access may make getting amendment materials and placement equipment to the remediation area more challenging.	The limited amount of amendment materials and placement equipment can easily be brought into readily accessible areas.	Laboratory treatability tests have shown amendments are likely effective.	The pilot test demonstrated that implementation equipment is available. If an amendment such as ZVI is used adequate supply could be an issue.	Similar approaches have been approved at other sites.	
5.	Thin-Layer Placement + MNR + ICs	✓	✓✓	✓✓	✓✓	✓✓	• Easier to implement in readily accessible areas. • More implementable than the removal alternatives in areas with limited access. • Pilot test demonstrated the alternative is implementable on mudflats. • Will have minimal impact on habitat. • Pilot study monitoring of thin-layer placement indicates that the sediment returns to the pre-addition elevation as a result of consolidation and compaction of underlying sediment. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Requires less transport and placement than removal alternatives. Limited access may make getting materials and placement equipment to the remediation area more challenging.	The limited amount of thin-layer materials and placement equipment can easily be brought into readily accessible areas.	Pilot test demonstrated alternative is implementable.	The pilot test demonstrated that implementation equipment is available. Common materials.	Similar approaches have been approved at other sites.	

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA Not Applicable**

Table 6-2: Implementability Evaluation of Waterway Alternatives, Berry's Creek Study Area

	Alternative	Area Accessibility[1]		Alternative Characteristics[2]			Summary Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility: Availability of Remedial Resources[4]	Administrative Feasibility: Ability to Obtain Regulatory Approvals[5]	
6.	Thin-Layer Placement with Amendment + MNR + ICs	✓	✓✓	✓✓	✓✓	✓✓	• Easier to implement in readily accessible areas. • More implementable than the removal alternatives in areas with limited access. • Pilot test demonstrated the alternative is implementable on mudflats. • Will have minimal impact on habitat. • Pilot study monitoring of thin-layer placement indicates that the sediment returns to the pre addition elevation as a result of consolidation and compaction of underlying sediment. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Requires less transport and placement than removal alternatives. Limited access may make getting amendment, materials, and placement equipment to the remediation area more challenging	The limited amount of thin-layer and amendment materials and placement equipment can easily be brought into readily accessible areas.	The pilot test demonstrated that the alternative is implementable.	The pilot test demonstrated that implementation equipment is available. Common materials; the volume required may stress local supply	Similar approaches have been approved at other sites.	
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	**0**	✓	✓	✓✓	✓✓	• Would be difficult to implement in areas with limited access. • Large scale intrusive activity could destabilize adjacent areas (e.g., slope stability issues). Restoration of waterway channels and mudflat areas can be challenging and requires careful consideration of hydrodynamics and bed geomorphology to avoid destabilizing portions of the waterways or adjacent marshes. • Need to manage environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Limited access will make getting equipment and materials in and out difficult. Will likely result in significant collateral habitat damage due to activities such as temporary road construction.	A partial-depth removal + capping action will present some challenges in even readily accessible areas.	Equipment and technology are available. Maintaining and restoring channel stability may be challenging.	Resources and landfill capacity should be available for partial removal of contaminated sediment.	A relatively common remedial approach that has been approved at other sites.	

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

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Table 6-2: Implementability Evaluation of Waterway Alternatives, Berry's Creek Study Area

	Alternative	Area Accessibility[1]		Alternative Characteristics[2]			Summary Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility: Availability of Remedial Resources[4]	Administrative Feasibility: Ability to Obtain Regulatory Approvals[5]	
8.	Full-depth Contaminated Sediment Removal (without Backfill) + MNR + ICs	0	✓	X	✓	✓✓	• Would be difficult to implement in areas with limited access. • Significant removal volume could pose a challenge for managing sediment disposal and daily landfill capacity. • Maintaining channel stability may be challenging during the removal action; without backfill it may not be possible to maintain long-term channel stability. • Need to manage environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Limited access will make getting equipment and materials in and out difficult. Will likely result in significant collateral habitat damage due to activities such as temporary road construction.	A large full-depth removal action will present some challenges in even readily accessible areas.	Equipment and technology are available. Removal without backfill would result in significant hydrodynamic changes to the work area and areas up and downstream. These changes may destabilize channels and marshes in a natural system as new flow and sediment transport patterns become established. If performed on small scale or targeted areas, these issues may be less of a consideration.	A large scale full-depth removal could pose challenges from a local transportation perspective as well as from a disposal perspective related to daily landfill capacity and facilities, especially if BCSA remediation is implemented concurrent with other major regional sediment remediation projects.	A relatively common remedial approach that has been approved at other sites.	
9.	Full-depth Contaminated Sediment Removal + Backfill + MNR +ICs	0	✓	✓	✓	✓✓	• Would be difficult to implement in areas with limited access. • Significant removal volume could be a problem for managing sediment disposal and daily regional landfill capacity. • Large scale intrusive activity could destabilize adjacent areas (e.g., slope stability issues). Restoration of waterway channels and mudflat areas can be challenging and requires careful consideration of hydrodynamics and bed geomorphology to avoid destabilizing portions of the waterways or adjacent marshes. • Need to manage environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Limited access will make getting equipment and materials in and out difficult. Will likely result in significant collateral habitat damage due to activities such as temporary road construction.	A large full-depth removal action will present some challenges in even readily accessible areas.	Equipment and technology are available. Maintaining and restoring channel stability will be challenging.	A large scale full-depth removal could pose challenges from a disposal perspective related to daily landfill capacity and facilities.	A relatively common remedial approach that has been approved at other sites.	

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

Table 6-2: Implementability Evaluation of Waterway Alternatives, Berry's Creek Study Area

Notes:

1. Area Accessibility refers to the relative accessibility of the area, by land or water, for accessing the area with equipment and materials for remediation. Since specific SMUs cannot be identified at this time, the alternatives are evaluated for a broadly representative range of conditions in the BCSA. In the detailed evaluation stages of the Feasibility Study process; a given SMU can be compared to these conditions to identify the expected relative Implementability of an alternative to the specific conditions of that SMU. While there is a range of each of these general conditions within the BCSA, for the purposes of the DSRAM, each condition is broken down into two general ranges.
2. The Alternatives are also evaluated in the context of the characteristics of each Alternative that are not dependent on specific areas; specifically Technical Implementability and Administrative Feasibility.
3. Technical Implementability is used to assess factors such as the ability to construct and meet technical challenges such as the difficulty in designing a program to restore/maintain an area (such as effective implementation and will the alternative return a waterway channel to a stable geometry), whether the alternative is an established remedial measure, and quality control challenges.
4. Availability of Resources considers if there are materials, disposal services and capacity, equipment, and technical specialists necessary for Alternative implementation readily available in the general area of the BCSA.
5. Ability to Obtain Regulatory Approvals is an assessment of whether the Alternative would be readily approved by EPA and others in the regulatory community from a permit-equivalency standpoint.

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

Table 6-3: Cost Evaluation of the Waterway Alternatives, Berry's Creek Study Area

Alternative		Relative Cost	Summary Comments
1.	No Action	**NA**	• CERCLA required alternative. No screening performed.
2.	Institutional Controls (ICs) (alone)	✓✓	• Nominal cost. • Cost elements include signage and the cost of developing use restrictions.
3.	Monitored Natural Recovery + ICs	✓	• Minimal cost. • Cost elements include periodic monitoring of the recovery progress including sampling and analysis and data evaluation.
4.	Direct Application of Treatment Amendment + MNR + ICs	**0**	• Lowest cost Alternative after Alternatives 1, 2, and 3. • Cost elements include purchasing and application of amendments. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation. • In an ASM approach, additional applications may be required.

Legend

✓✓ Very Low Cost ✓ Low Cost **0** Mid-range Cost **X** High Cost **XX** Very High Cost **NA** Not Applicable

Table 6-3: Cost Evaluation of the Waterway Alternatives, Berry's Creek Study Area

Alternative		Relative Cost	Summary Comments
5.	Thin-Layer Placement + MNR + ICs	**0**	• Similar, but likely slightly less cost than Alternative 6. • Cost elements include purchasing and placement of the thin layer material. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation. • In an ASM approach, additional placement, within the initially covered area or adjacent areas, may be required.
6.	Thin-Layer Placement with Amendment + MNR + ICs	**0**	• Slightly more cost than Alternative 5 due to the amendment material, however, the overall cost difference will not be significant compared to other alternatives. • Cost elements include purchasing and placement of the thin layer material and amendment. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation. • In an ASM approach, additional placement, within the initially covered area or adjacent areas, may be required.
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	**XX**	• Less cost than Alternative 9, likely less expensive than Alternative 8 although dependent on depth of removal. • Cost elements include sediment removal and disposal cost, purchase and placement of cap material, habitat restoration, and periodic monitoring and maintenance of

Legend

✓✓ Very Low Cost ✓ Low Cost **0** Mid-range Cost **X** High Cost **XX** Very High Cost **NA** Not Applicable

Table 6-3: Cost Evaluation of the Waterway Alternatives, Berry's Creek Study Area

	Alternative	Relative Cost	Summary Comments
			habitat and cap.
8.	Full-depth Contaminated Sediment Removal (without Backfill) + MNR + ICs	**XX**	• Less cost than Alternative 9, likely more expensive than Alternative 7 although dependent on depth of removal. • Cost elements include sediment removal and disposal cost.
9.	Full-depth Contaminated Sediment Removal + Backfill + MNR + ICs	**XX**	• Likely the highest cost Alternative. • Cost elements include sediment removal and disposal cost, purchase and placement of backfill material, habitat restoration, and periodic monitoring and maintenance of habitat.

Notes:

1. The Relative Cost evaluation is an assessment of the probable cost compared to the other identified Alternatives. It is generally based on experience and professional judgment.
2. Although two alternatives may be rated at the same Relative Cost, there will be cost differences. The differences are anticipated to be small compared to the range of cost for all of the alternatives; in other words, the cost difference does not justify a different Relative Cost rating.

Legend

✓✓ Very Low Cost ✓ Low Cost **0** Mid-range Cost **X** High Cost **XX** Very High Cost **NA** Not Applicable

Table 6-4: Effectiveness Evaluation of the Marsh Alternatives, Berry's Creek Study Area

	Alternative	Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
1.	No Action	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	• CERCLA required alternative, no screening performed.
2.	Institutional Controls (ICs) (alone)	**0**	**XX**	**NA**	**0**	**XX**	**0**	• ICs alone will not be effective outside of low risk areas that do not require monitoring. • ICs will not be effective for protection of ecological receptors except for where there is ongoing natural recovery. • Effectiveness for human health risk reduction depends on the ICs being followed. • ICs are considered as part of subsequent alternatives.
	Comments/Notes			The RI has shown the marshes to be very stable therefore consideration of Lower Stability areas is not applicable. If the RI identifies specific marsh subareas with lower stability, these will be evaluated on an area specific basis in the Detailed Alternatives Analysis.				
3.	Monitored Natural Recovery + ICs	✓✓	**XX**		✓✓	**0**	✓✓	• More effective in areas of lower risk. • More effective in areas with higher natural recovery occurring. • Effectiveness of MNR will be dependent on the implementation and effectiveness of the accompanying ICs.
	Comments/Notes		Longer timeframe for achieving RAOs.		No impact on habitat.			
4.	Direct Application of Treatment Amendment + MNR + ICs	✓✓	**X**		✓✓	✓	✓✓	• Will not provide barrier for isolation. • Effective in areas of lower risk. • More effective in areas with higher natural recovery occurring but still effective to a limited degree in areas of lower natural recovery because of treatment layer.
	Comments/Notes	Short term positive effects (i.e., reduced BAZ COPC concentrations) will be realized with the application of an amendment in the surface layer.	Single application may have limited long-term effect on higher COPC level areas. Multiple applications may be required to be effective.			Addition of amendments may enhance recovery by binding COPCs, even in low MNR areas.	Applied amendment enhances ongoing natural recovery.	

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-4: Effectiveness Screening of Marsh Alternatives, Berry's Creek Study Area

Alternative		Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
5.	Thin-Layer Placement + MNR + ICs	✓✓	0		✓✓	✓	✓✓	• Effective in areas of lower risk and higher stability. • Pilot studies have shown that thin-layer placement plots have remained in place. • More effective in areas with higher natural recovery occurring but still effective to a limited degree in areas of lower natural recovery. • Pilot studies have demonstrated thin-layer placement has reduced BAZ COPC concentrations.
	Comments/Notes	Short term positive effects (i.e., reduced BAZ COPC concentrations) will be realized with thin-layer placement.	Longer timeframe for achieving RAOs.		Pilot studies have shown thin-layer has remained in place. Will have minimal impact on habitat although pilot testing has shown at least short term inhibition of Phragmites regrowth.	Addition of a thin-layer may enhance recovery, even in low MNR areas.	Thin-layer placement enhances ongoing natural recovery.	
6.	Thin-Layer Placement with Amendment + MNR + ICs	✓✓	0		✓✓	✓	✓✓	• Effective in areas of lower risk and higher stability. • Will provide higher effectiveness in the short-term than Direct Application of Amendments and Thin-layer Placement w/o Amendments. • Pilot studies have shown that thin-layer placement plots have remained in place. • More effective in areas with higher natural recovery occurring but still effective to a limited degree in areas of lower natural recovery. • Pilot studies have demonstrated thin-layer placement has reduced BAZ concentrations.
	Comments/Notes	Short term positive effects (i.e., reduced BAZ COPC concentrations) will be realized sooner with thin-layer placement with amendment. This alternative combines the benefit of placement of clean materials on the surface with the additional benefit of amendments binding COPCs. The amendments may mitigate short-term risks related to sediment disturbance during placement.	Longer timeframe for achieving RAOs.		Pilot studies have shown thin-layer has remained in place. Will have minimal impact on habitat although pilot testing has shown at least short term inhibition of Phragmites regrowth.	Potential enhancement of natural recovery even for low MNR areas by combining thin-layer placement with a potentially COPC-binding amendment.	Thin-layer placement with amendment enhances ongoing natural recovery.	

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-4: Effectiveness Screening of Marsh Alternatives, Berry's Creek Study Area

Alternative		Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	X	✓		X	✓	0	• Effectively removes COPC mass from system. • Long-term benefits need to be balanced against short-term risks from removal activities. Sediment removal will result in environmental risks associated with excavation in marshes such as habitat disruption or loss and potential reexposure of residual contamination. In some circumstances, the long-term benefits would out-weigh the short-term risks. • Cap materials would help mitigate potential negative impacts and portions of these risks can be mitigated through careful planning of habitat restoration, however, replacement and restoration of marshes in a tidal estuary can be challenging.
	Comments/Notes	Short-term risks from removal activities (i.e., habitat disturbance/loss, resuspension, release of COPCs from bedded sediments, and the presence of residuals) likely outweigh the long-term benefits.	The long-term benefits of removal will likely outweigh the increased short-term risks (i.e., habitat disturbance/loss resuspension, release and redistribution of COPCs from bedded sediments, and the presence of residuals), but the risks must be managed effectively.		In high stability areas, the potential short- and long-term risks related to disruption of a stable marsh habitat (i.e. habitat disturbance/loss, reduced storm resiliency from loss of Phragmites, etc.) may outweigh the long-term benefits. Portions of these risks can be mitigated through careful planning of habitat restoration, however, replacement and restoration of marshes in a tidal estuary can be challenging and must factor in critical marsh surface elevations in relation to tidal inundation, sea-level rise, regulatory fill restrictions, geotechnical considerations, and biological requirements. However, the alternative may still be appropriate to implement in stable areas based on risk considerations.	In areas with lower natural recovery, the long-term benefits may outweigh the risks if NR unlikely to achieve RAOs for a given area.	In areas with higher natural recovery, the long-term benefits may not outweigh the risks if NR progressing toward RAOs for a given area.	

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-4: Effectiveness Screening of Marsh Alternatives, Berry's Creek Study Area

Alternative		Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
8.	Full-depth Contaminated Sediment Removal (without Backfill) + MNR + ICs	**X**	**0**		**X**	**0**	**0**	• Effectively removes COPC mass from system. • Long-term benefits need to be balanced against short-term risks from removal activities. Sediment removal will result in environmental risks associated with excavation in marshes such as habitat disruption or loss and potential reexposure of residual contamination. For this alternative, the permanent loss of marsh habitat and accompanying reduced resiliency to storms would likely outweigh the benefits. In some circumstances, the long-term benefits would outweigh the short-term risks. • If permanent habitat loss considered in effectiveness evaluation, alternative would not be effective.
	Comments/Notes	Short-term risks from removal activities (i.e., habitat disturbance/loss, resuspension, release of COPCs from bedded sediments, and the presence of residuals) likely outweigh the long-term benefits.	The long-term benefits of removal may not outweigh the impact of habitat loss.		Removal without backfilling will permanently remove a portion of the marsh.	In areas with lower natural recovery, the long-term benefits may not outweigh the impact of habitat loss.	In areas with higher natural recovery, the long-term benefits may not outweigh the risks if NR progressing toward RAOs for a given area.	

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-4: Effectiveness Screening of Marsh Alternatives, Berry's Creek Study Area

Alternative		Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
9.	Full-depth Contaminated Sediment Removal + Backfill + MNR + ICs	X	✓		X	✓	0	• Effectively removes COPC mass from system. • Long-term benefits need to be balanced against short-term risks from removal activities. Sediment removal will result in environmental risks associated with excavation in marshes such as habitat disruption or loss and potential reexposure of residual contamination. In some circumstances, the long-term benefits would out-weigh the short-term risks. • Backfill materials would help mitigate potential negative impacts and portions of these risks can be mitigated through careful planning of habitat restoration, however, replacement and restoration of marshes in a tidal estuary can be challenging.
	Comments/Notes	Short-term risks from removal activities (i.e., habitat disturbance/loss, resuspension, release of COPCs from bedded sediments, and the presence of residuals) likely outweigh the long-term benefits.	The long-term benefits of removal will likely outweigh the increased short-term risks (i.e., habitat disturbance/loss resuspension, release and redistribution of COPCs from bedded sediments, and the presence of residuals), but the risks must be managed effectively.		In high stability areas, the potential short- and long-term risks related to disruption of a stable marsh habitat (i.e. habitat disturbance/loss, reduced storm resiliency from loss of Phragmites, etc.) may outweigh the long-term benefits. Portions of these risks can be mitigated through careful planning of habitat restoration, however, replacement and restoration of marshes in a tidal estuary can be challenging and must factor in critical marsh surface elevations in relation to tidal inundation, sea-level rise, regulatory fill restrictions, geotechnical considerations, and biological requirements. However, the alternative may still be appropriate to implement in stable areas based on risk considerations.	In areas with lower natural recovery, the long-term benefits may outweigh the risks if NR unlikely to achieve RAOs for a given area.	In areas with higher natural recovery, the long-term benefits may not outweigh the risks if NR progressing toward RAOs for a given area.	

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-4: Effectiveness Screening of Marsh Alternatives, Berry's Creek Study Area

Alternative		Area Characteristics and Alternative Evaluation[1]						Summary Comments
		Area Risk[2]		Area Stability[3]		Natural Recovery[4]		
		Lower Risk	Higher Risk	Lower Stability	Higher Stability	Lower NR	Higher NR	
10.	Hydraulic/Hydrologic Controls + MNR + ICs	✓	0		✓	✓	0	• Most effective in areas of lower risk and lower natural recovery. • Hydrodynamic controls could be used to increase natural recovery and/or to reduce potential exchange from impacted areas to unimpacted areas. • Design of hydraulic controls that reduce inundation will need to consider that limiting the influx of sediment to the marshes will impact ongoing natural recovery. • Designs that change inundation patterns will need to consider potential impact on existing habitat.
	Comments/Notes	Hydraulic/hydrologic controls could be designed to enhance ongoing risk reduction and/or reduce potential exchange from impacted areas to unimpacted areas.	In high risk areas, hydraulic/hydrologic controls can be designed to reduce potential exchange from impacted areas to unimpacted areas and to encourage natural recovery through deposition of cleaner sediments. However, longer timeframes may be needed to achieve RAOs in higher risk areas.		Hydraulic/hydrologic controls can be designed to reduce potential exchange from impacted areas to unimpacted areas and to encourage natural recovery through deposition of cleaner sediments. Hydrologic and sediment balances would need to be carefully considered to avoid potential adverse effects such as insufficient sediment delivery or inundation frequency to maintain stable areas.	Hydrodynamic controls could be used to increase NR and reduce potential exchange of sediments from impacted to unimpacted areas.	In areas with higher natural recovery the potential risks of hydraulic/hydrologic controls such as negative changes to sediment balance may outweigh potential benefits.	

Notes:

1. Both short-term and long-term Effectiveness of alternatives are considered in the evaluation. The Effectiveness of alternatives is considered in relation to general categories of conditions such as Risk, Stability, and Natural Recovery conditions. Since specific SMUs are not identified at this time, the alternatives are evaluated for a broadly representative range of conditions in the BCSA. In the detailed evaluation stages of the Feasibility Study process; a given SMU can be compared to these conditions to identify the expected relative Effectiveness of an alternative to the specific conditions of that SMU. While there is a range of each of these general conditions within the BCSA, for the purposes of the DSRAM, each condition is broken down into two general ranges. How specific actual conditions may fall within these categories remains to be determined through the continued Remedial Investigation and Risk Assessment analysis.
2. Area Risk refers to the relative human health or ecological risk posed by an area based on Risk Assessment evaluations and is generally representative of the relative COPC concentration range (e.g. high, medium, low). The ranges of actual risks present in the BCSA remain to be determined as well as what specific conditions may be determined to represent higher or lower risk.
3. Area Stability refers to whether the physical, chemical and biological conditions within the area are likely to remain stable over time. Conditions such as physical makeup of the sediment, observed physical stability of sediment, geochronology, and hydrologic conditions would be considered to evaluate the stability of an area. Other conditions such as physical features would be considered in the stability evaluation of a given SMU. The RI has shown there are no unstable areas within the marshes, which is a difference from the waterways.
4. Natural Recovery refers to whether near surface COPC concentrations are decreasing over time. This analysis considers multiple lines of evidence, but one primary consideration is whether there is indication of deposition of "clean" sediment as evidenced by bulk COPC concentrations in shallow sediments that are progressively lower over time compared to deeper sediment layers (in areas where there is elevated deeper COPC concentrations). Similarly, in areas with low concentrations in deeper sediment, shallow sediment concentrations that remain consistently low would be indicative of on-going natural recovery. Areas that are recovering naturally would have reduced risk over time even without remedial intervention.

Legend

✓✓ Highly Effective ✓ Effective **0** Possibly Effective **X** Likely not Effective **XX** Not Effective **NA** Not Applicable

Table 6-5: Implementability Evaluation of Marsh Alternatives, Berry's Creek Study Area

	Alternative	Area Accessibility[1]		Alternative Characteristics[2]			Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility		
					Availability of Remedial Resources[4]	Ability to Obtain Regulatory Approvals[5]	
1.	No Action	**NA**	**NA**	**NA**	**NA**	**NA**	• CERCLA required alternative, no screening performed.
2.	Institutional Controls (ICs) (alone)	✓✓	✓✓	✓✓	✓✓	✓✓	• Implementable - would be limited to signage and possibly fencing.
	Comments/Notes						
3.	Monitored Natural Recovery + ICs	✓✓	✓✓	✓✓	✓✓	✓✓	• Access will not be an issue as no material is brought in or out. • The alternative should be approvable from a permit equivalency standpoint.
	Comments/Notes					Similar approaches have been approved at other sites.	
4.	Direct Application of Treatment Amendment + MNR + ICs	✓	✓✓	✓✓	✓✓	✓✓	• Easier to implement in readily accessible areas. • More implementable than the removal alternatives in areas with limited access. • Laboratory treatability tests have shown amendments are likely effective; however, pilot studies are required. • Will have very limited to no impact on habitat. Phragmites will reestablish through the amendment layer. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Requires less transport and placement than removal alternatives. Limited access may make getting amendment materials and placement equipment to the remediation area more challenging.	The limited amount of amendment materials and placement equipment can easily be brought into readily accessible areas.	Laboratory treatability tests have shown amendments are likely effective.	The pilot test demonstrated that implementation equipment is available. If an amendment such as ZVI is used adequate supply could be an issue.	Similar approaches have been approved at other sites.	
5.	Thin-Layer Placement + MNR + ICs	✓	✓✓	✓✓	✓✓	✓	• Easier to implement in readily accessible areas. • More implementable than the removal alternatives in areas with limited access. • Pilot test demonstrated the alternative is implementable in the marshes. • Will have limited impact on habitat; however, not as much as other alternatives. Phragmites will reestablish through the placement layer. • Will need to address ARAR issues associated with work in wetlands as part of the regulatory approval process. • Construction activity may negatively impact marsh integrity. • Permit equivalencies will need to consider NJDEP and USACE requirements for wetland areas. However, this alternative avoids and reduces disturbances compared to removal alternatives.
	Comments/Notes	Requires less transport and placement than removal alternatives. Limited access may make getting materials and placement equipment to the remediation area more challenging	The limited amount of thin-layer materials and placement equipment can easily be brought into readily accessible areas.	Pilot test demonstrated alternative is implementable.	The pilot test demonstrated that implementation equipment is available. Common materials.	No net fill requirements would be addressed as part of the regulatory approval process. However, thin-layer placement in marshes may not result in a net elevation change long-term considering settlement and consolidation/degradation of organic materials. Alternative may provide net benefits (e.g. off-set sea-level rise, potential habitat improvements through diversity of wetland types, etc.)	

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

Table 6-5: Implementability Evaluation of Marsh Alternatives, Berry's Creek Study Area

Alternative		Area Accessibility[1]		Alternative Characteristics[2]			Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility		
					Availability of Remedial Resources[4]	Ability to Obtain Regulatory Approvals[5]	
6.	Thin-Layer Placement with Amendment + MNR + ICs	✓	✓✓	✓✓	✓✓	✓	• Easier to implement in readily accessible areas. • More implementable than the removal alternatives in areas with limited access. • Pilot test demonstrated the alternative is implementable on mudflats. • Will have limited impact on habitat; however, not as much as other alternatives. Phragmites will reestablish through the placement layer. • Will need to address ARAR issues such as filling within wetlands. • Construction activity may negatively impact marsh integrity. • Permit equivalencies will need to consider NJDEP and USACE requirements for wetland areas. However this alternative avoids and reduces disturbances compared to removal alternatives.
	Comments/Notes	Limited access will make transportation of thin-layer materials to the remediation area a challenge.	The limited amount of thin-layer and amendment materials can easily be brought into readily accessible areas.	Pilot test demonstrated alternative is implementable.	The pilot test demonstrated that implementation equipment is available. Common materials; the volume required may stress local supply.	No net fill requirements would be addressed as part of the regulatory approval process. However, thin-layer placement in marshes may not result in a net elevation change long-term considering settlement and consolidation/degradation of organic materials. Alternative may provide net benefits (e.g. off-set sea-level rise, potential habitat improvements through diversity of wetland types, etc.)	
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	0	✓	X	0	0	• May not be practical in difficult to access areas. • Significant volume removal could pose a challenge for managing sediment disposal and daily landfill capacity. • A generally acceptable remedial action to regulators. • Need to manage environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • Construction will negatively impact marsh integrity. • Permit equivalencies will need to consider NJDEP and USACE requirements for wetland areas.
	Comments/Notes	Limited access will make getting equipment and materials in and out difficult.	A partial-depth removal + capping action will present some challenges in even readily accessible areas.	Equipment and technology are available. Restoration of marshes will be difficult to achieve considering sensitivity of environment and challenges related to design elevation and habitat creation.	A large scale partial-depth removal could pose challenges from a local transportation perspective as well as from a disposal perspective related to daily landfill capacity and facilities, especially if BCSA remediation is implemented concurrent with other major regional sediment remediation projects.	Excavation and disturbance of the wetlands will require consideration of permit equivalencies related to NJDEP and USACE requirements including USACE considerations related to avoidance, minimization and compensatory mitigation.	

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

Table 6-5: Implementability Evaluation of Marsh Alternatives, Berry's Creek Study Area

	Alternative	Area Accessibility[1]		Alternative Characteristics[2]			Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility		
					Availability of Remedial Resources[4]	Ability to Obtain Regulatory Approvals[5]	
8.	Full-depth Contaminated Sediment Removal (without Backfill) + MNR + ICs	**0**	✓	**X**	**0**	**XX**	• May not be practical in difficult to access areas. • Significant volume removal could pose a challenge for managing sediment disposal and daily landfill capacity. • A generally acceptable remedial action to regulators. • Need to manage environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • Construction will negatively impact marsh integrity. • Permit equivalencies will need to consider NJDEP and USACE requirements for wetland areas. Permanent loss of marshes is not expected to meet regulatory requirements.
	Comments/Notes	Limited access will make getting equipment and materials in and out difficult.	A large full-depth removal action will present some challenges in even readily accessible areas.	Equipment and technology is available. Excavation without backfill presents challenges related to marsh stability	A large scale full-depth removal could pose challenges from a local transportation perspective as well as from a disposal perspective related to daily landfill capacity and facilities, especially if BCSA remediation is implemented concurrent with other major regional sediment remediation projects.	Excavation and disturbance of the wetlands will require consideration of permit equivalencies related to NJDEP and USACE requirements including USACE considerations related to avoidance, minimization and compensatory mitigation. Permanent loss of marshes is not expected to meet regulatory requirements.	
9.	Full-depth Contaminated Sediment Removal + Backfill + MNR + ICs	**0**	✓	**X**	**0**	**0**	• May not be practical in difficult to access areas. • Significant volume removal could pose a challenge for managing sediment disposal and daily landfill capacity. • Need to manage environmental risks associated with dredging such as resuspension of the bed sediment, release of contaminants from bedded and suspended sediments, and residual contamination. • Construction will negatively impact marsh integrity. • Permit equivalencies will need to consider NJDEP and USACE requirements for wetland areas.
	Comments/Notes	Limited access will make getting equipment and materials in and out difficult.	A large full-depth removal action will present some challenges in even readily accessible areas.	Equipment and technology is available. Restoration of marshes will be difficult to achieve considering sensitivity of environment and challenges related to design elevation and habitat creation.	A large scale full-depth removal could pose challenges from a local transportation perspective as well as from a disposal perspective related to daily landfill capacity and facilities, especially if BCSA remediation is implemented concurrent with other major regional sediment remediation projects.	Excavation and disturbance of the wetlands will require consideration of permit equivalencies related to NJDEP and USACE requirements including USACE considerations related to avoidance, minimization and compensatory mitigation.	

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

Table 6-5: Implementability Evaluation of Marsh Alternatives, Berry's Creek Study Area

	Alternative	Area Accessibility[1]		Alternative Characteristics[2]			Comments
		Less Accessible	Readily Accessible	Technical Implementa-bility[3]	Administrative Feasibility		
					Availability of Remedial Resources[4]	Ability to Obtain Regulatory Approvals[5]	
10.	Hydraulic/Hydrologic Controls + MNR + ICs	✓	✓✓	0	✓✓	✓	• Hydrodynamic controls would be implementable even for less accessible areas if controls target features such as marsh tributaries/channels. However, larger controls would pose greater challenges. • Anticipated construction such as active control weirs or tidegates, marsh channel realignment, storm drain realignment, and tide gates are common. • Altering hydrodynamic conditions could be used to help alleviate flooding. However, there is also the potential that if not implemented properly it could exacerbate flooding. • Hydrologic and sediment balances would need to be carefully considered to avoid potential adverse effects such as insufficient sediment delivery or inundation frequency to maintain stability and natural recovery conditions where present. • Hydrodynamic controls could be part of other alternatives. • The alternative should be approvable from a permit-equivalency standpoint.
	Comments/Notes	Depending on the scale of selected hydraulic/hydrologic controls, the structures may be relatively small in size (e.g. if targeting marsh tributaries) so less material and equipment would need to be transported to and from the work area. However, if larger scale controls are considered, less accessible areas would pose challenges.	Anticipated construction activities will be very implementable in the readily accessible marsh areas. However, if larger scale controls are considered, accessibility could pose challenges.	Activities such as active control weirs or tidegates, marsh channel realignment, storm drain realignment, and tide gates are commonly implemented. However, hydrologic and sediment balances would need to be carefully considered to avoid potential adverse effects such as insufficient sediment delivery or inundation frequency to maintain stable areas.	Equipment readily available.	Hydraulic/hydrologic controls will require consideration of permit equivalencies related to NJDEP and USACE requirements including USACE considerations related to avoidance, minimization and compensatory mitigation.	

Notes:

1. Area Accessibility refers to the relative accessibility of the area, by land or water, for accessing the area with equipment and materials for remediation. Since specific SMUs cannot be identified at this time, the alternatives are evaluated for a broadly representative range of conditions in the BCSA. In the detailed evaluation stages of the Feasibility Study process; a given SMU can be compared to these conditions to identify the expected relative Implementability of an alternative to the specific conditions of that SMU. While there is a range of each of these general conditions within the BCSA, for the purposes of the DSRAM, each condition is broken down into two general ranges.
2. The Alternatives are also evaluated in the context of the characteristics of each Alternative that are not dependent on specific areas; specifically Technical Implementability and Administrative Feasibility.
3. Technical Implementability is used to assess factors such as the ability to construct and meet technical challenges such as the difficulty in designing a program to restore/maintain an area (such as effective implementation and will the alternative return a waterway channel to a stable geometry), whether the alternative is an established remedial measure, and quality control challenges.
4. Availability of Resources considers if there are materials, disposal services and capacity, equipment, and technical specialists necessary for Alternative implementation readily available in the general area of the BCSA.
5. Ability to Obtain Regulatory Approvals is an assessment of whether the Alternative would be readily approved by EPA and others in the regulatory community from a permit equivalency standpoint.

Legend

✓✓ Highly Implementable ✓ Implementable **0** Possibly Implementable **X** Likely not Implementable **XX** Not Implementable **NA** Not Applicable

Table 6-6: Cost Evaluation of the Marsh Alternatives, Berry's Creek Study Area

Alternative		Relative Cost	Summary Comments
1.	No Action	**NA**	• CERCLA required alternative. No screening performed.
2.	Institutional Controls (ICs) (alone)	✓✓	• Nominal cost. • Cost elements include signage, fencing, and the cost of developing use restrictions.
3.	Monitored Natural Recovery + ICs	✓	• Minimal cost. • Cost elements include periodic monitoring including sampling and analysis and data evaluation.
4.	Direct Application of Treatment Amendment + MNR + ICs	**0**	• Lowest cost Alternative after Alternatives 1, 2, and 3. • Cost elements include purchasing and application of amendments. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation. • In an ASM approach additional applications may be required.
5.	Thin-Layer Placement + MNR + ICs	**0**	• Similar, but likely slightly less cost than Alternative 6. • Cost elements include purchasing and placement of the thin layer material. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation. • In an ASM approach, additional placement, within the initially covered area or adjacent areas, may be required.

Legend

✓✓ Very Low Cost ✓ Low Cost **0** Mid-range Cost **X** High Cost **XX** Very High Cost **NA** Not Applicable

Table 6-6: Cost Evaluation of the Marsh Alternatives, Berry's Creek Study Area

Alternative		Relative Cost	Summary Comments
6.	Thin-Layer Placement with Amendment + MNR + IC	**0**	• Slightly more cost than Alternative 5 due to the amendment material, however, the overall cost difference will not be significant compared to other alternatives. • Cost elements include purchasing and placement of the thin layer material and amendment. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation. • In an ASM approach, additional placement, within the initially covered area or adjacent areas, may be required.
7.	Partial Contaminated Sediment Removal + Capping + MNR + ICs	**XX**	• Less cost than Alternative 9, likely less expensive than Alternative 8 although dependent on depth of removal. • Cost elements include sediment removal and disposal cost, purchase and placement of cap material, habitat restoration, and periodic monitoring and maintenance of habitat and cap.
8.	Full-depth Contaminated Sediment Removal+ MNR + ICs	**XX**	• Less cost than Alternative 9, likely more expensive than Alternative 7 although dependent on depth of removal. • Cost elements include sediment removal and disposal cost.
9.	Full-depth Contaminated Sediment Removal + Backfill + MNR + ICs	**XX**	• Likely the highest cost Alternative. • Cost elements include sediment removal and disposal cost, purchase and placement of backfill material, habitat restoration, and periodic monitoring and maintenance of habitat.

Legend

✓✓ Very Low Cost ✓ Low Cost **0** Mid-range Cost **X** High Cost **XX** Very High Cost **NA** Not Applicable

Table 6-6: Cost Evaluation of the Marsh Alternatives, Berry's Creek Study Area

Alternative		Relative Cost	Summary Comments
10.	Hydraulic/Hydrologic Controls + IC + MNR	✓	• Cost elements are dependent on the specific hydraulic/hydrologic control approach. This could include the cost of filling or capping mosquito ditches or other marsh channels; marsh channel relocation; berms, or tide gates. • Cost elements also include periodic monitoring of the recovery progress including sampling and analysis and data evaluation.

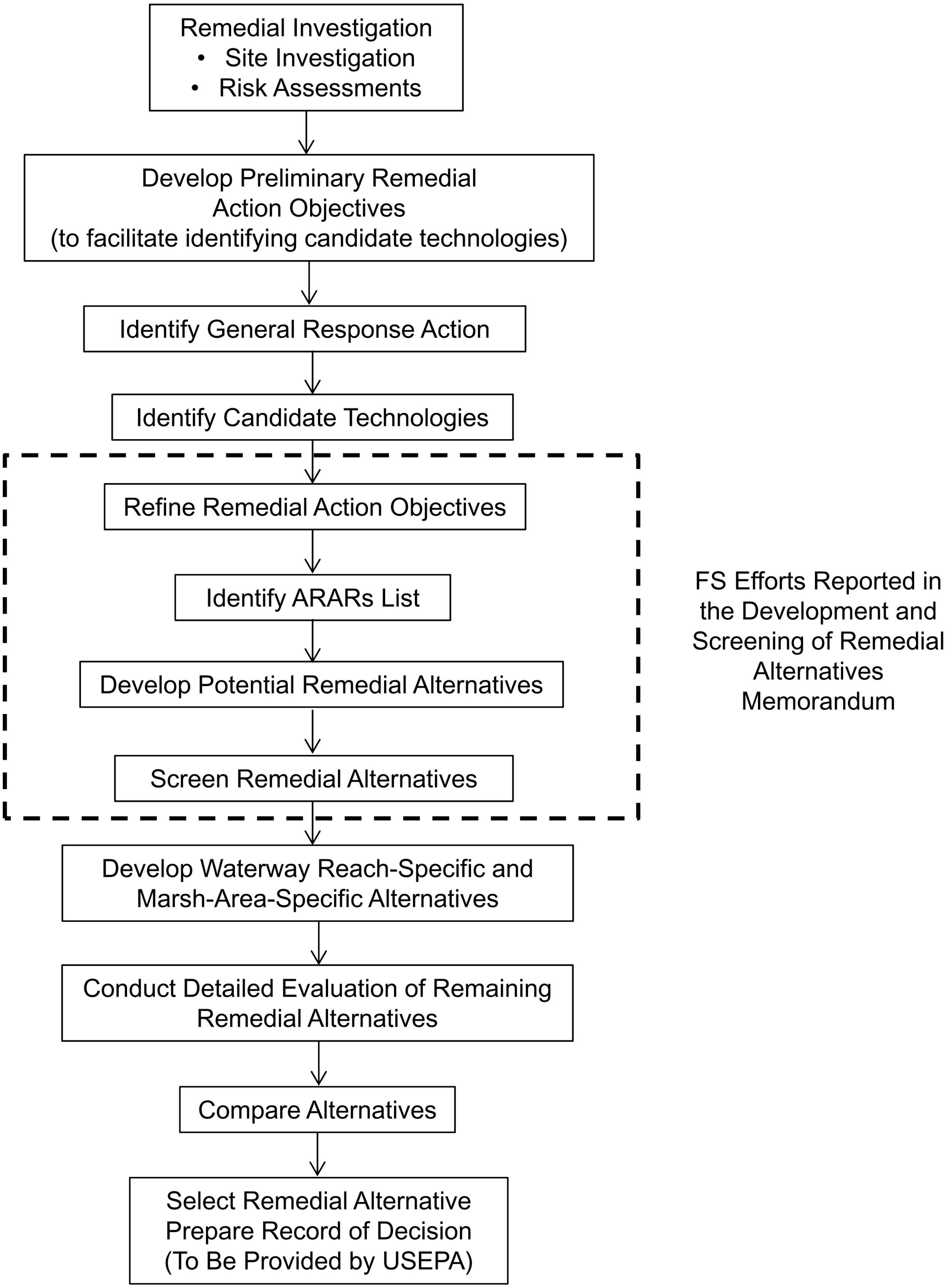
Notes:

1. The Relative Cost evaluation is an assessment of the probable cost compared to the other identified Alternatives. It is generally based on experience and professional judgment.
2. Although two alternatives may be rated at the same Relative Cost, there will be cost differences. The differences are anticipated to be small compared to the range of cost for all of the alternatives; in other words, the cost difference does not justify a different Relative Cost rating.

Legend

✓✓ Very Low Cost ✓ Low Cost **0** Mid-range Cost **X** High Cost **XX** Very High Cost **NA** Not Applicable

Figures

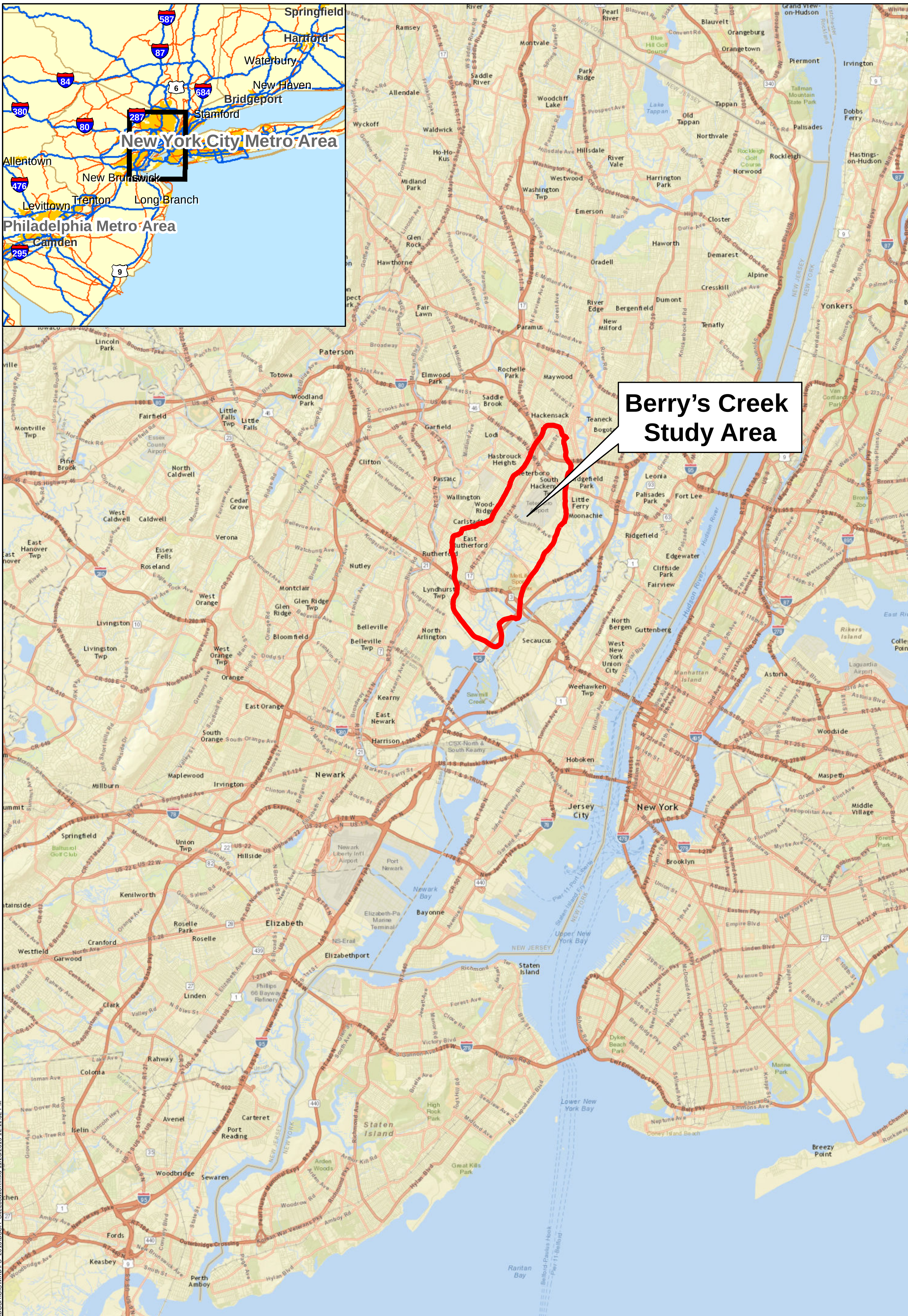


Notes:

Status of the BCSA
Remedial Investigation / Feasibility Study Process

Development and Screening of Remedial Alternatives Memorandum
Berry's Creek Study Area Feasibility Study

Figure 1-1



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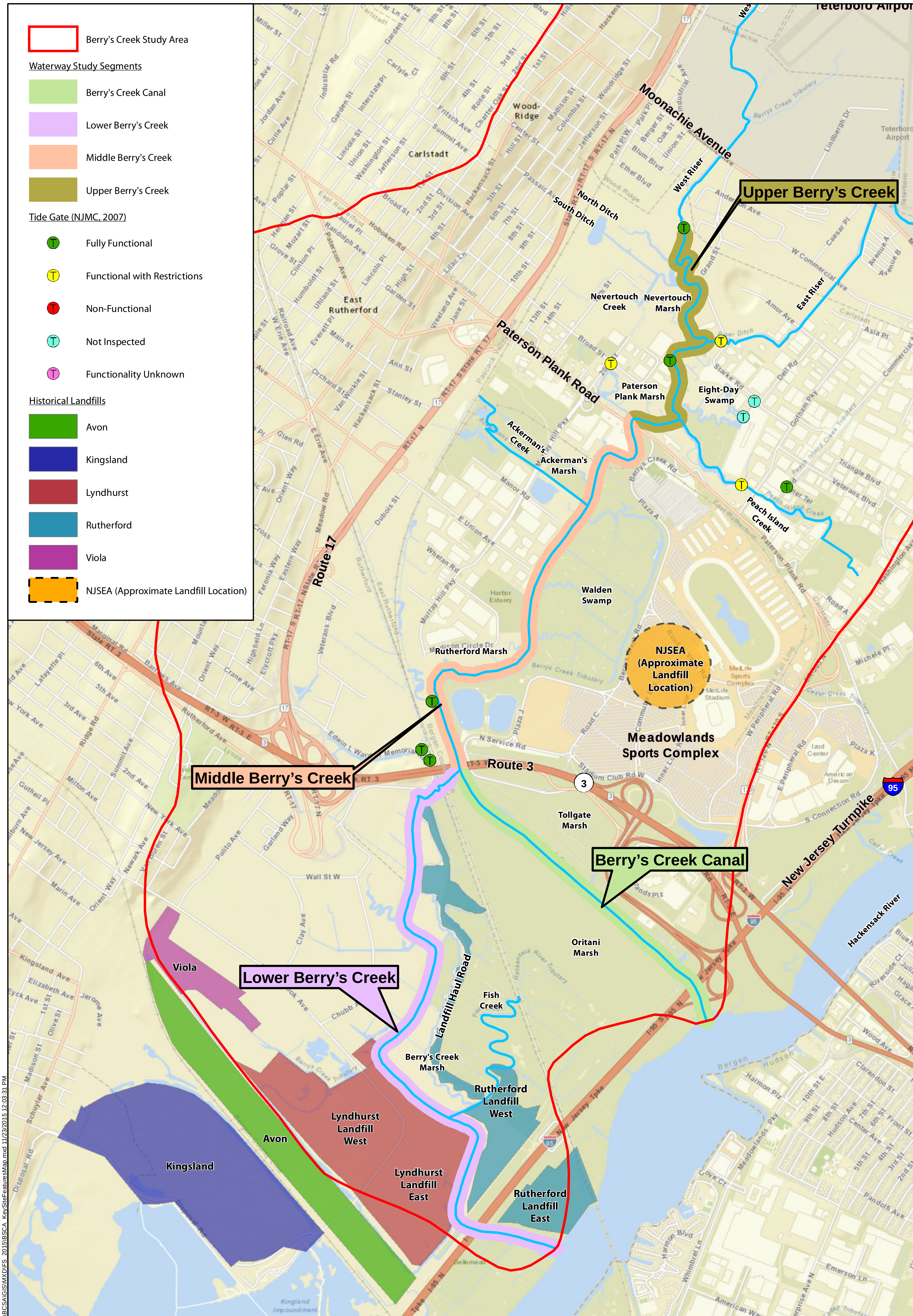
Berry's Creek Study Area Site Location

Development and Screening of Remedial Alternatives Memorandum
Berry's Creek Study Area Feasibility Study

Figure
1-2



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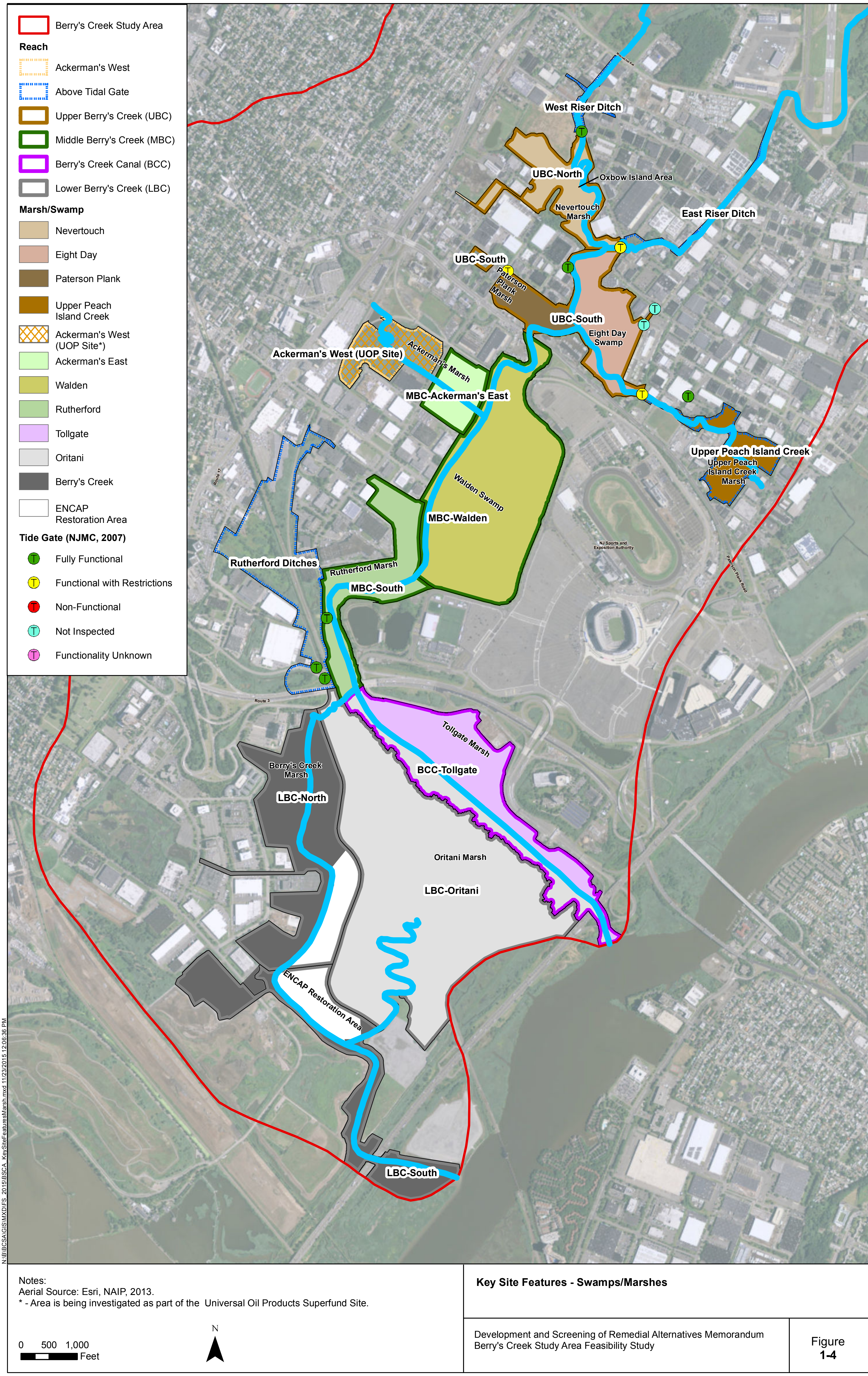
Key Waterway Study Segment Features in BCSA

Development and Screening of Remedial Alternatives Memorandum
Berry's Creek Study Area Feasibility Study

Figure 1-3



Notes:
Aerial Source: Esri, NAIP, 2013.
* - Area is being investigated as part of the Universal Oil Products Superfund Site.

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Key Site Features - Swamps/Marshes

Development and Screening of Remedial Alternatives Memorandum
Berry's Creek Study Area Feasibility Study

Figure 1-4